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TITLE

LEADING EDGE CONCEPTS AND ATTACHMENTS - PRELIMINARY

NO. OF PAGES 139

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3.1 SUMMARY

3.1.1 A series of five leading edge concepts were subjected to three separate environment test programs. Each configuration was exposed to a sonic environment, a thermal gradient test, a second sonic exposure, and finally, a static load test. The purpose of these tests was to evaluate these five basic leading edge concepts and their various design features to obtain information for a production configuration and to verify analytical procedures.

3.1.2 The Phase A of the sonic test program (LT-5-617-1A-Reference 1) consisted of the exposure of each specimen to a random noise environment of 152.5 db SPL* (overall) for 30 minutes.

3.1.3 The heat test program (LT-5-617-2-Reference 1) consisted of subjecting each specimen to four 2700°F. heat cycles of forty minutes duration, and one 3000°F. heat cycle of ten minutes duration. The data collected was used to determine design temperature distribution.

3.1.4 After the heat program each specimen was exposed to a sonic environment of 152.5 db SPL (overall) for 30 minutes and then to 155.5 db for an additional 30 minutes, according to Phase B of LT-5-617-1-Reference 1).

3.1.5 The load program (LT-5-617-3-Reference 1) consisted of slow-load testing five specimen configurations (detailed on drawings number 25-20341, 25-20367, 25-20372, 25-20376, and 25-20378) at a rate of 180 pounds per minutes, and rapid-load testing of two specimen configurations (detailed on drawings number 25-20341 and 25-20376) at a rate of 94,000 pounds per minute. All specimens were instrumented with deflection clips used in conjunction with the photographic-deflection-measurement technique. Four of the slow-load tested specimens (25-20367, 25-20372, 25-20376, and 25-20378) were instrumented with rosette strain gages.

*SPL - Sonic Pressure Level

3.2 TABLE OF CONTENTS

3.3 REFERENCES

1. D2-6783-1 Structural Integrity Development and Test Program - Detail Plan - Structures Technology
2. Leading Edge Segment - Forward Body (Test Only) 25-20372
3. Leading Edge Segment - Forward Body (Test Only) 25-20378
4. Leading Edge Segment - Stiffened (Test Only) 25-20367
5. Leading Edge Segment - Forward Body - Unstiffened (Test Only) 25-20341
6. Leading Edge Segment - Forward Body - Riveted (Test Only) 25-20376
7. Support Assembly of Leading Edge Segment - Forward Body (Test Only) 25-20355
8. Support Installation of Leading Edge Segment - Forward Body (Test Only) 25-20375

3.3.1 PHOTOGRAPH AND ILLUSTRATION INDEX

3.3.1 (Continued)

3.3.1 (Continued)

3.3.1 (Continued)

3.4 INTRODUCTION

In November of 1960 five forward body leading edge concepts were chosen for evaluation. A total of ten specimens were subjected to simulated flight test conditions for comparative evaluation. The following sequence of tests were performed on the specimens:

1. Sonic - 152.5 db normal incident random sound.
2. Thermal cycles - Four cycles to 2700° F.
   One cycle to 3000° F.
3. Sonic - 155.5 db normal incident random sound.
4. Ultimate Load - Load rates 180 pounds per minute and 94,000 pounds per minute.

These tests were conducted to obtain fatigue, thermal stress, and oxidation resistance properties since empirical test data was required to evaluate complex structures and to verify analytical design procedures.

This is the third section of three of D2-80085 covering the testing of X-20 leading edge concepts and consists of three volumes. See Sections 1 and 2 for plasma jet shroud testing of concepts having the same external configuration.

3.5 TEST SPECIMEN AND INSTRUMENTATION

3.5.1 Test Specimen

3.5.1.1 A typical leading edge test specimen assembly, mounted and ready for sonic testing, is shown in Figure 3-1. Each specimen assembly consisted of two parts: (1) A leading edge segment fabricated from molybdenum -0.5% titanium alloy with an oxidation-resistant coating of molybdenum disilicide; and (2) a backup structure from Rene' 41 material. During thermal cycling, simulated heat shields coated with Mo-.5Ti skin were added as shown in Figure 3-2 to provide the proper thermal environment on the leading edge and leading edge beam.

3.5.1.2 Two preliminary coating processes were used to apply the molybdenum disilicide coating: (1) SPZ-1 (pack cementation); and (2) SPZ-4 (fluidized bed). The process by which the coating was applied varied with each specimen and is tabulated below:

Boeing Drawing Number 1	Specimen No. 1	Description	Coating Process
25-20372	1	DS L.E. Unstiffened Single Shell	SPZ-1
25-20372	2	DS L.E. Unstiffened Single Shell	SPZ-1
25-20367	1	DS L.E. Double Skin Long Segments	SPZ-1
25-20367	2	DS L.E. Double Skin Long Segments	SPZ-4
25-20378	1	DS L.E. Double Skin Short Segments	SPZ-4
25-20378	2	DS L.E. Double Skin Short Segments	SPZ-4
25-20341	1	DS L.E. Unstiffened Shell Corners Reinforced Single Shell	SPZ-1
25-20341	2	DS L.E. Unstiffened Shell Corners Reinforced Single Shell	SPZ-1
25-20376	1	DS L.E. Riveted Ribs Single Shell	SPZ-4 Details SPZ-1 Assembly
25-20376	2	DS L.E. Riveted Ribs Single Shell	SPZ-4 Details SPZ-1 Assembly

1 Boeing drawing lot and specimen numbers are used interchangeably as dash numbers to the basic Boeing drawing number in this document.

3.5.2 Instrumentation

3.5.2.1 For the sonic test phase, two non-contact deflection pickups were used to monitor the specimen structural response and the sonic environment was monitored with one Altec 21BR-200 microphone located in front of each specimen as shown in Fig. 3-3.

3.5.2.2 For the thermal cycle test phase, each specimen was instrumented with eleven, 22 gage, refrasil insulated, chromel vs. alumel thermocouples, and eighteen platinum vs. platinum 13% rhodium alloy thermocouple probes.

3.5.2.2.1 The chromel vs. alumel thermocouples were spot welded to the Rene 41 backup structure, and the platinum probes were positioned on the leading edge segment and heat shields.

3.5.2.2.2 The probe type thermocouples consisted of a platinum vs. platinum 13% rhodium alloy thermocouple encased in a 12-inch long, 0.125-inch diameter alumina insulator. The thermocouple was spotwelded to a 0.025-inch thick platinum disc, 0.250-inch in diameter, which was then flame sprayed with a 0.005-inch layer of alumina to prevent reaction of platinum with the disilicide coating. Spring loaded holders (Fig. 3-4) were used to position the probes against the test specimen surface.

3.5.2.2.3 Monitor thermocouple locations are shown in Figs. 3-5 through 3-14. and control thermocouple locations are shown in Fig. 3-15 and 3-16.

3.5.2.3 All of the specimens that were load tested were instrumented with deflection clips used with the photographic-deflection-measurement technique. Clip locations are shown in Figure 3-17. Four of the specimens tested (detailed on drawings number 25-20367, 25-20372, 25-20376, and 25-20378) were also instrumented with rosette strain gages as shown in Figures 3-18 through 3-21. Photographs of each specimen in Figures 3-22 through 3-31 illustrate instrumentation before testing.

3.6 TEST SETUP

3.6.1 For sonic testing, the leading edge test specimen backup structure was bolted to a steel jig (Fig. 3-1) which was, in turn, bolted to floor tie-down rails such that the specimen leading edge was positioned approximately three feet inside the progressive wave horn chamber (Fig. 3-32).

3.6.1.1 The random noise source consisted of four Altec-Lansing Model 6786 electro-pneumatic transducers mounted at the throat of the progressive wave horn (Fig. 3-33). Power to the transducers was supplied by two 200 watt McIntosh Amplifiers. Shaping of the test spectrum was accomplished using an Allison 3-man-9 noise generator and octave band equalizer. A schematic diagram of the facility control system is shown in Fig. 3-34.

3.6.2 The test fixture used for thermally cycling the leading edge specimens is shown in Fig. 3-35. The specimens were held in position on a table of alumina brick with "L" shaped clamping bolts. A stainless steel support, shaped to conform to the curvature of the leading edge, positioned the lamps. The fixture was hinged so the lamp assemblies could be rotated up and away to facilitate specimen installation and inspection. Fig. 3-36 shows the test fixture in the open position.

3.6.2.1 General Electric 1600T3 quartz tube heating elements were used in air-cooled ceramic reflectors. The cooling air was distributed to each lamp assembly by means of an aluminum alloy manifold and copper tubing. The lamps were installed approximately one-half to three-quarters of an inch above the specimen surface.

3.6.2.2 Seven heat control zones were used. Each control zone required an ignitron power controller and an operator to manually control it. The required heat programs were drawn on the strip chart of the respective control recorders. During the test the operators manually adjusted the power to raise or lower the heat input to the specimen according to the program demand. A single Leeds-Northrup Speedomap G recorder was used for each control zone at a chart speed of six inches per minute. The temperature traces for each heat cycle were produced with a different color ink so the same programs could be re-used.

3.6.2.3 The external surface of the heat shield was not to exceed 2700° F. Since the control thermocouple was internally mounted, an extra recorder was used for each heat shield to monitor the external surface temperature. The chart speed for these recorders was one-half inch per minute.

3.6.3 The test fixture for load testing is shown in Figure 3-37. Load was applied through a loading head consisting of a curved rubber block backed up by wood and aluminum. The applied load was reacted through a back-up structure on which the specimen was mounted.

3.6.3.1 Two sheets of teflon were placed between the rubber and specimen to decrease friction and to minimize tangential loads on the curved surface of the specimen. Cutouts in the teflon which allowed clearance for the rosette gages and lead wires were filled with potting compound to maintain load continuity over the test specimen surface.

3.6.3.2 The setup sequence upon receipt of each specimen was to install gages and deflection clips, install teflon sheets, pot the cutouts, and mount the specimen in the test fixture.

3.7 TEST PROCEDURE

3.7.1 Sonic Test Program LT 5-617-1 (Fig. 3-38)

3.7.1.1 Each specimen was exposed to a random noise environment of 152.5 db SPL (overall) for 30 minutes. The microphone and deflection pickups were tape recorded during the initial portion of each test phase for later spectral analysis and amplitude distribution analysis. Octave band analysis was made at the start of each test.

3.7.1.2 The specimens, upon return from thermal cycling per LT 5-617-2, (see 3.7.2) were subjected to an additional 30 minutes at 152.5 db. An octave band analysis of the microphone and deflection pickup outputs were again tape recorded during the first 10 minutes of the test. After 15 minutes the test was interrupted for specimen inspection after which the remaining 15 minutes of testing were completed.

3.7.1.3 The final phase of the sonic test program consisted of subjecting each test specimen to a random noise environment of 155.5 db SPL (overall) for 30 minutes. The spectrum of this phase was 3 db higher in all octave bands than the previous phases. The specimens were visually inspected at 5 minutes, 15 minutes, and at the conclusion of the 30 minute test. The output of the microphone and the two deflection pickups were tape recorded at the beginning of the test. A 5 cps bandwidth power spectral density analysis was made of the microphone and pickup outputs for the first and final test periods for each specimen. This data was stored with sonic test facility.

3.7.2 Heat Test Program LT 5-617-2 (Figs. 3-39 and 3-40)

3.7.2.1 The test specimens were delivered to the Heat Laboratory after completion of the initial phase of the sonic test program. To facilitate the temperature control of the backup structure and simulated heat shields, the fibrefrax insulation between them was removed for testing and chromel vs. alumel thermocouples were spotwelded to the backup structure. The specimen was positioned on the alumina brick test bed and locked in place with "L" shaped bolts. One-eighth inch fibrefrax board was cut to fit snugly in the ends of the specimen to reduce air circulation. The final step in specimen preparation was to mount the thermocouple probe-type sensors on the external surface.

3.7.2.2 Each leading edge test specimen was subjected to the heat program shown in Fig. 3-39 and 3-40. The heat program consisted of four 40 minute heat cycles followed by a 10 minute heat pulse. Maximum temperatures of 2700°F during the 40 minute cycle and 3000°F during the 10 minute pulse were attained. The simulated heat shields were subjected to two or three of the above-mentioned heat programs because only four sets of heat shields were fabricated for the ten leading edge heat programs conducted. Where failures to the disilicide coating on the simulated heat shields had occurred, Sears Roebuck furnace cement was applied to retard further erosion.

3.7.3 Room Temperature Load Test LT5-617-3

3.7.3.1 Five specimens, 25-20367, 25-20372, 25-20376, 25-20378, and 25-20341, were slow-load tested at 180 pounds per minute, and two specimens, 25-20341-2 and 25-20376-2, were rapid-load tested at 94,000 pounds per minute.

3.7.3.2 The four slow-load specimens, 25-20367, 25-20372, 25-20376, and 25-20378, were instrumented with rosette strain gages and loaded in increments of 100 pounds. Strain data recorded was recorded at each load increment.

3.7.3.3 During the loading of the specimens, photographs were taken of the specimens and the load dial simultaneously at regular intervals (ten-second intervals for slow-loading and sixteen frames per second for the rapid-loading). The motion of graduated clips and pointed screws attached to the specimen at critical deflection points was recorded relative to a grid placed over the camera lens. Fig. 3-41 shows a typical specimen with zero load and maximum load. The grid indicates the deflection.

3.8 TEST RESULTS

3.8.1 Sonic Test

3.8.1.1 None of the ten specimens tested developed visible failures due to sonic excitation. Photos of the tested specimens are shown in Figs. 3-42 through 3-52.

3.8.1.2 All ten sonic environment amplitudes exceeded the required peak/rms ratio of 3. Plots showing the test runs with the minimum and the maximum amplitude distribution curves are on Fig. 3-110. All of the other test runs were within these limits.

3.8.1.3 Plots of the sonic test spectrum for each specimen tested are shown on Figs. 3-111 through 3-120.

3.8.2 Thermal Cycle Test

3.8.2.1 Time versus temperature strip chart records of each control thermocouple were obtained for each specimen. No data was reduced from these records except the plots for typical test runs as shown in Figs. 3-53 through 3-58.

3.8.2.2 The monitor thermocouple tabulated data has been included in this report in Volumes 2 and 3. For comparative purposes, photographs of specimens before and after heat cyclic testing are presented in Figs. 3-59 through 3-86.

3.8.3 Room Temperature Load Test

3.8.3.1 Load versus deflection data is tabulated for each of the slow-load specimens in Volume 3 of this document. All rosette strain gage data is presented in Volume 3.

3.8.3.2 Load versus time curves for the two rapid-load specimens and load versus deflection data are presented in Volume 3. For specimen 25-20376-2, the first load cycle was considered invalid (see 3.9.2.3), so none of the data was tabulated.

3.8.3.3 Photographs of all of the specimens after load testing are presented in Figs. 3-87 through 3-104. X-ray photographs of the slow-load tested specimens are presented in Figs. 3-105 through 3-109.

3.9 TEST OBSERVATIONS

3.9.1 Thermal Gradient Test

3.9.1.1 Specimen 25-20372-1

Before the heat test, the surface of the leading edge was mottled and pitted, but there were no breaks in the disilicide coating (Fig. 3-59). Three minutes after the start of the third cycle, the test was halted due to a short circuit between two lamps. The lamps and a thermocouple had to be repaired. Then testing was completed. No tabulated data was recorded after 700 seconds in the third cycle due to a cracked recording head in the digital data system. After the heat test (Fig. 3-60), there was no apparent coating failure.

3.9.1.2 Specimen 25-20372-2

Fig. 3-61 shows pretest condition, and Fig. 3-62 shows no coating failures after 5 tests.

3.9.1.3 Specimen 25-20367-1

Fig. 3-63 shows pretest condition. There was no noticeable damage to the specimen after 5 heat cycles (Fig. 3-64 and 3-65).

3.9.1.4 Specimen 25-20367-2

Fig. 3-66 shows pretest condition. The heat shields from a previous test were reused on this specimen. Fig. 3-67 and 3-68 show post test results. The eroded heat shields have been repaired with Sears Roebuck Furnace Cement. The coating on the leading edge segment became a little mottled, but no failures occurred.

3.9.1.5 Specimen 25-20378-1

Fig. 3-69 shows pretest condition. During the second heat cycle, a platinum thermocouple came in contact with the heat shield under Zone 1 and caused a small hole to erode (Fig. 3-70). The hole was patched with Sears Roebuck Furnace Cement and testing continued. After the fourth heat cycle, it was found that Zone 2 had been overheated an undetermined amount (Figs. 3-70 and 3-71). This was apparently caused by the control thermocouple shifting position during the test. Fig. 3-72 shows the Zone 7 side. Fig. 3-73 shows coating failure after 3000°F heat pulse.

3.9.1.6 Specimen 25-20378-2

Fig. 3-74 shows the heat shield on Zone 1 side of specimen eroded around edges. The coating failed around some of the rivets, and a one-quarter inch hole eroded under the control thermocouple. Fig. 3-75 shows the area under Zone 6 glazed due to over-heating, and a small hole eroded at the control thermocouple location.

3.9.1.7 [illegible]

3.9.1.7 Specimen 25-20341-1

Fig. 3-76 shows pretest condition and Fig. 3-77 shows no noticeable coating failure after heat tests. The ten minute heat pulse had to be repeated. An over-temperature switch was set incorrectly and the power to Zone 4 was cut off each time the temperature exceeded 2200°F.

3.9.1.8 Specimen 25-20341-2

Fig. 3-78 shows pretest condition. Figs. 3-79 and 3-80 show specimen after heat tests. A rivet on the Zone 7 heat shield failed during tests.

3.9.1.9 Specimen 25-20376-1

The hole around the rivet on the leading edge, seen in the pretest photo in Fig. 3-81, was a manufacturing error. The heat shields had been used previously on 25-20378-2. Fig. 3-82 and 3-83 shows post-test condition. Only noticeable damage was further erosion of heat shields.

3.9.1.10 Specimen 25-20376-2

Fig. 3-84 shows pretest condition. One of the heat shields was cracked when it was mounted on the backup structure (Fig. 3-85). It was sealed with furnace cement. During the heat cycles, two rivets eroded in the heat shield (Fig. 3-86). There was no coating failure to the leading edge.

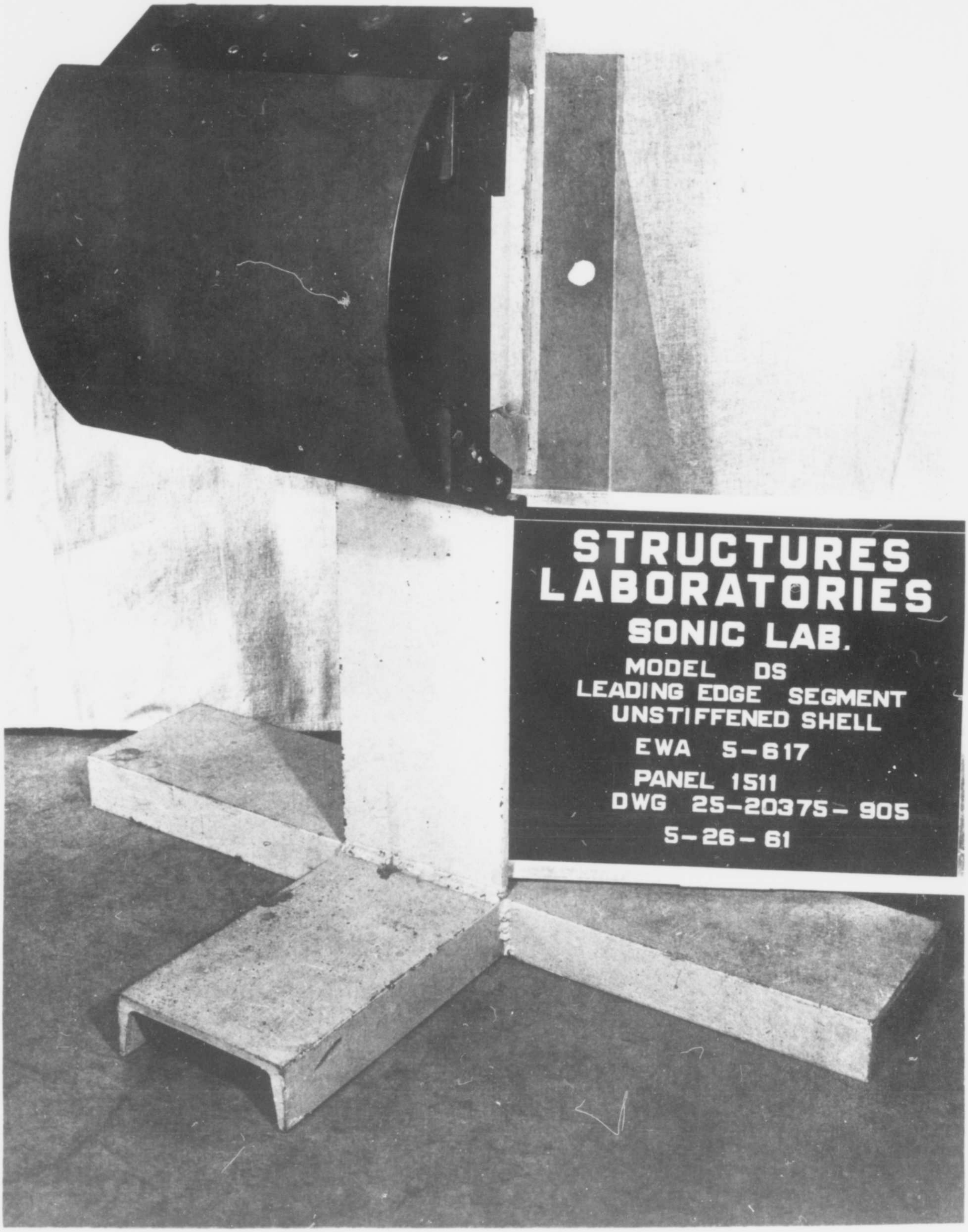
3.9.2 <u>Load Test</u>

3.9.2.1 Specimen 25-20376 failed at a load of 1988 pounds by brittle fracture of structural elements (Figs. 3-96, 3-97, 3-98, and 3-109) when it was slow-load tested.

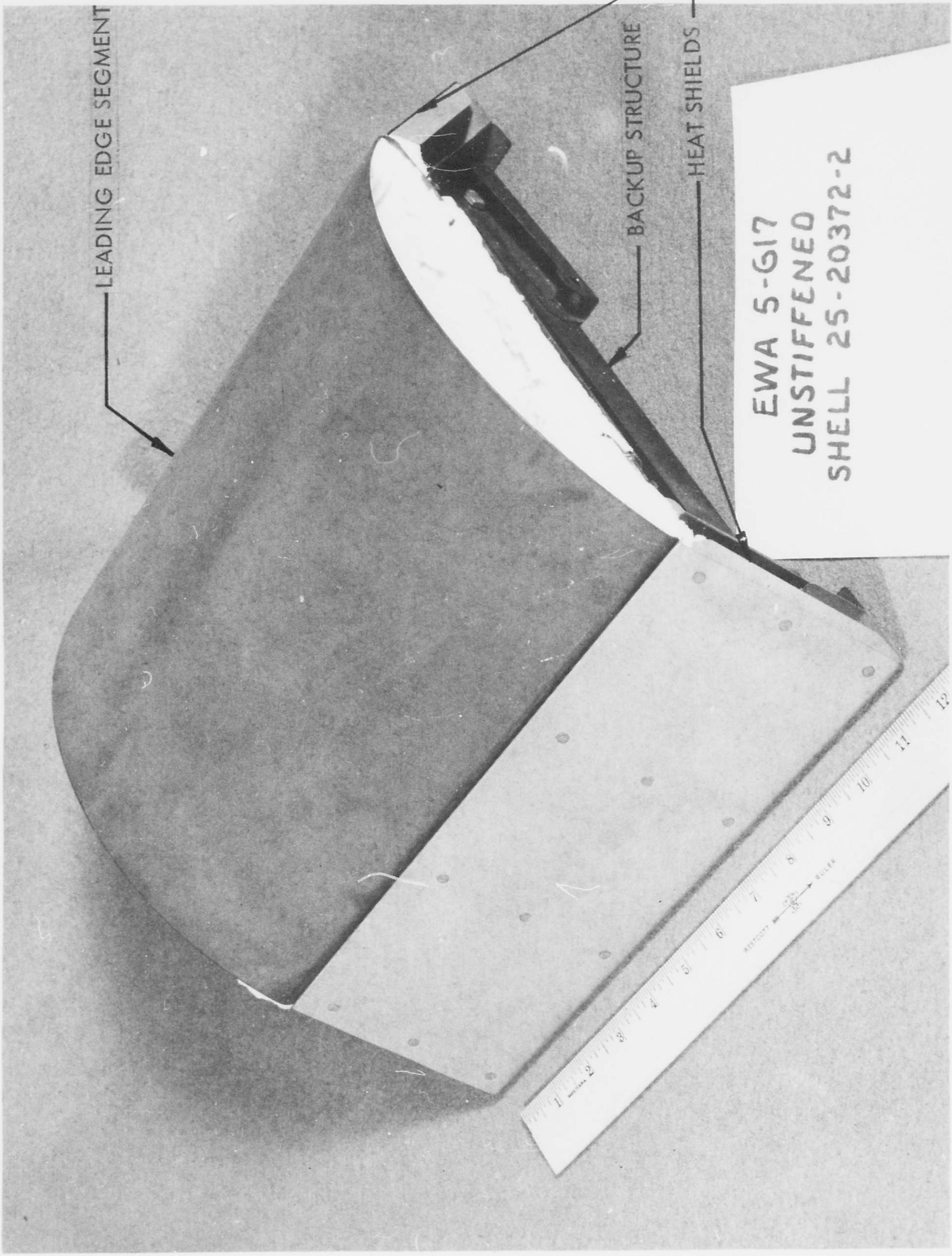
3.9.2.2 The slow-load tests, on the first four specimens, resulted in unexpectedly high loads and plastic deformations. The possibility that strain-rate-sensitivity of the specimen material (Mo-0.5 Ti) would alter these results under higher load rates prompted further investigation through the rapid-load test program.

3.9.2.3 Both rapid-load specimens were inadvertently unloaded by an improperly set deflection switch. The switch was supposed to be set so the loading would be halted on failure of the specimen. Each specimen was loaded a second time to accomplish the desired test.

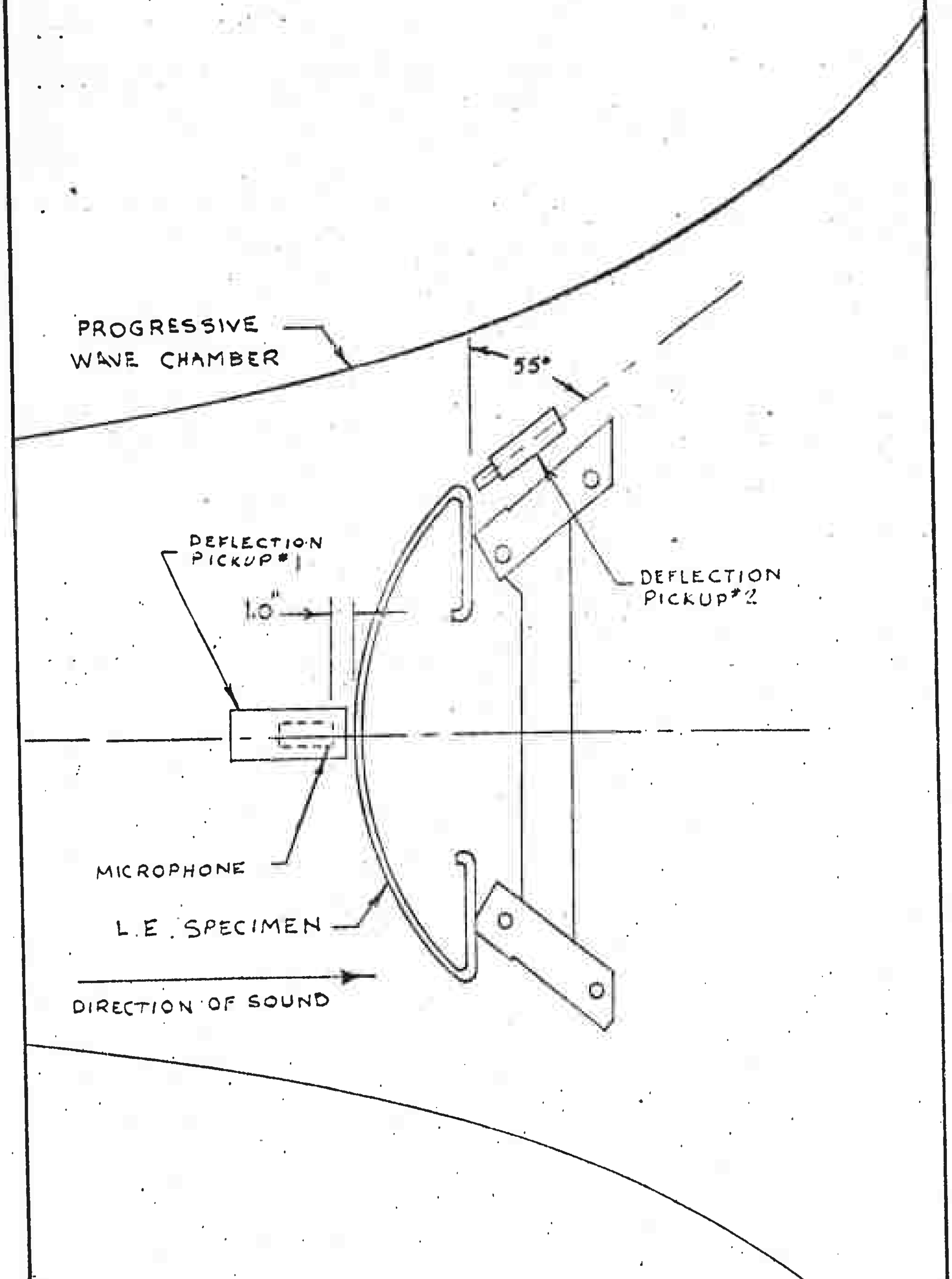
3.9.2.4 Specimen 25-20341-2 failed initially at a load of 1100 pounds when rapid-load tested. A delay in the test machine unloading system resulted in a maximum load of 2900 pounds being applied to the backup structure. Fig. 3-100 shows the failed specimen.



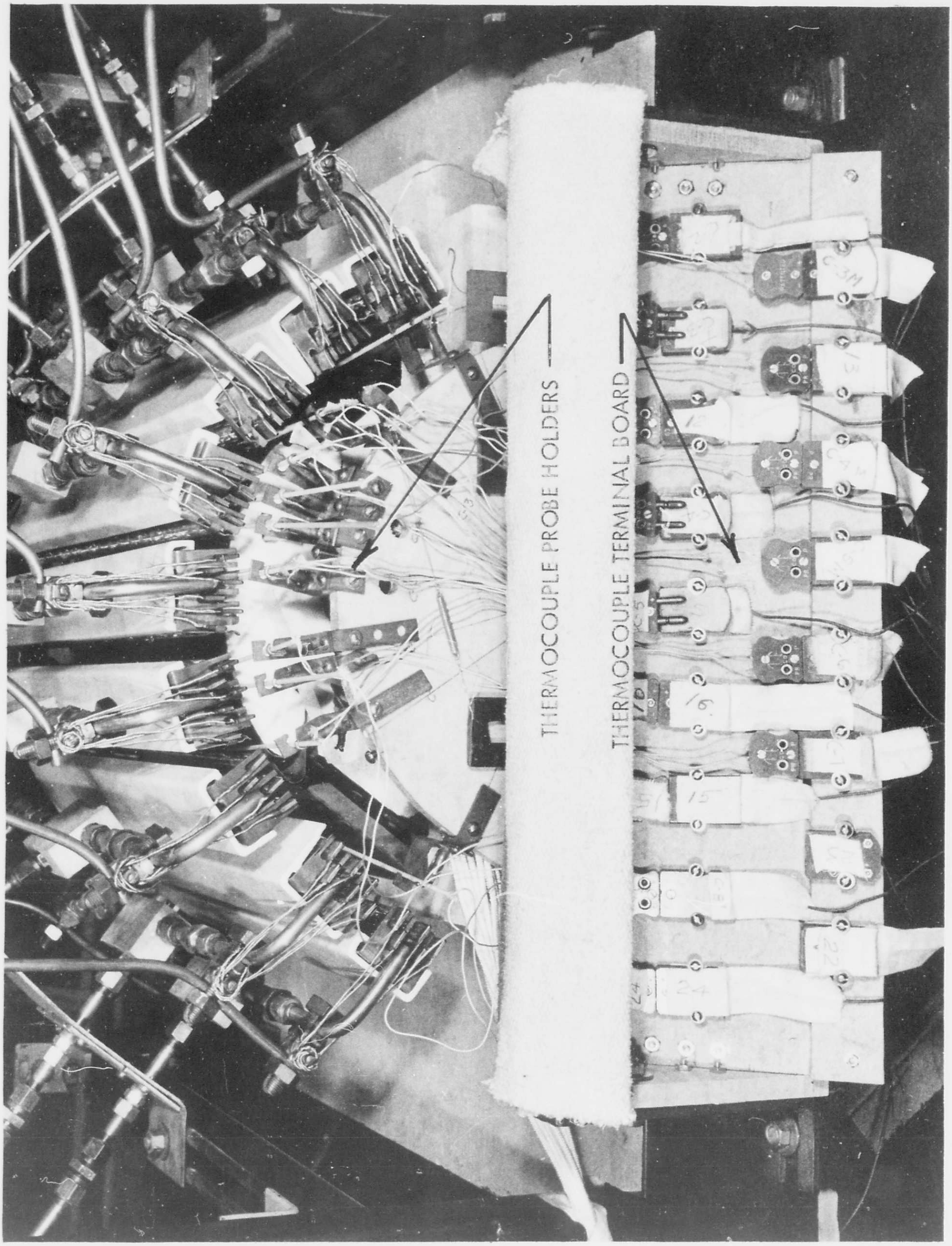
TYPICAL LEADING EDGE ON SONIC TEST FIXTURE
SPECIMEN MOUNTED



TYPICAL LEADING EDGE SPECIMEN WITH HEAT SHIELDS INSTALLED

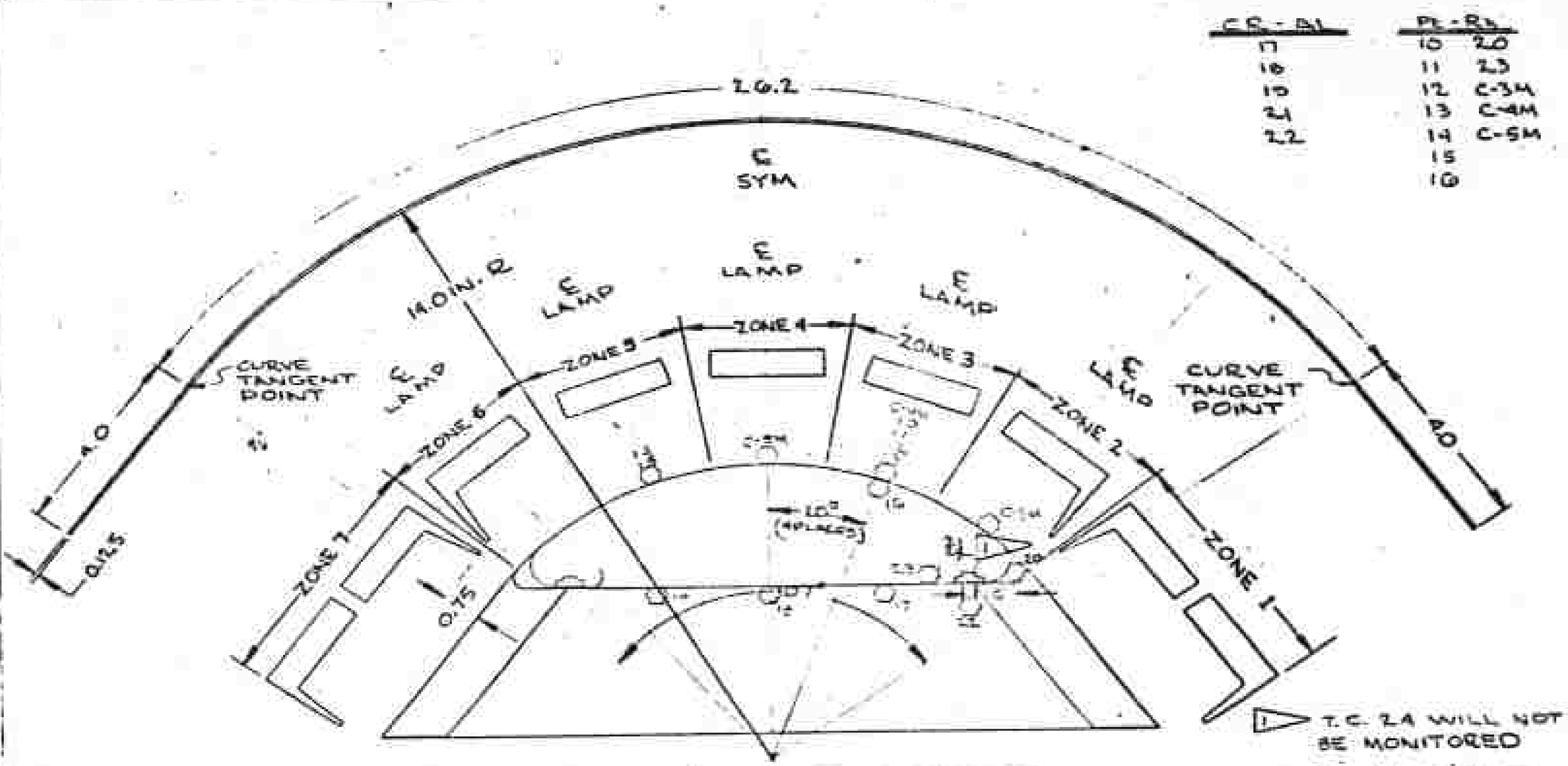


SONIC TEST INSTRUMENTATION LOCATIONS



THERMOCOUPLE PROBE HOLDERS AND TERMINAL BOARD

35

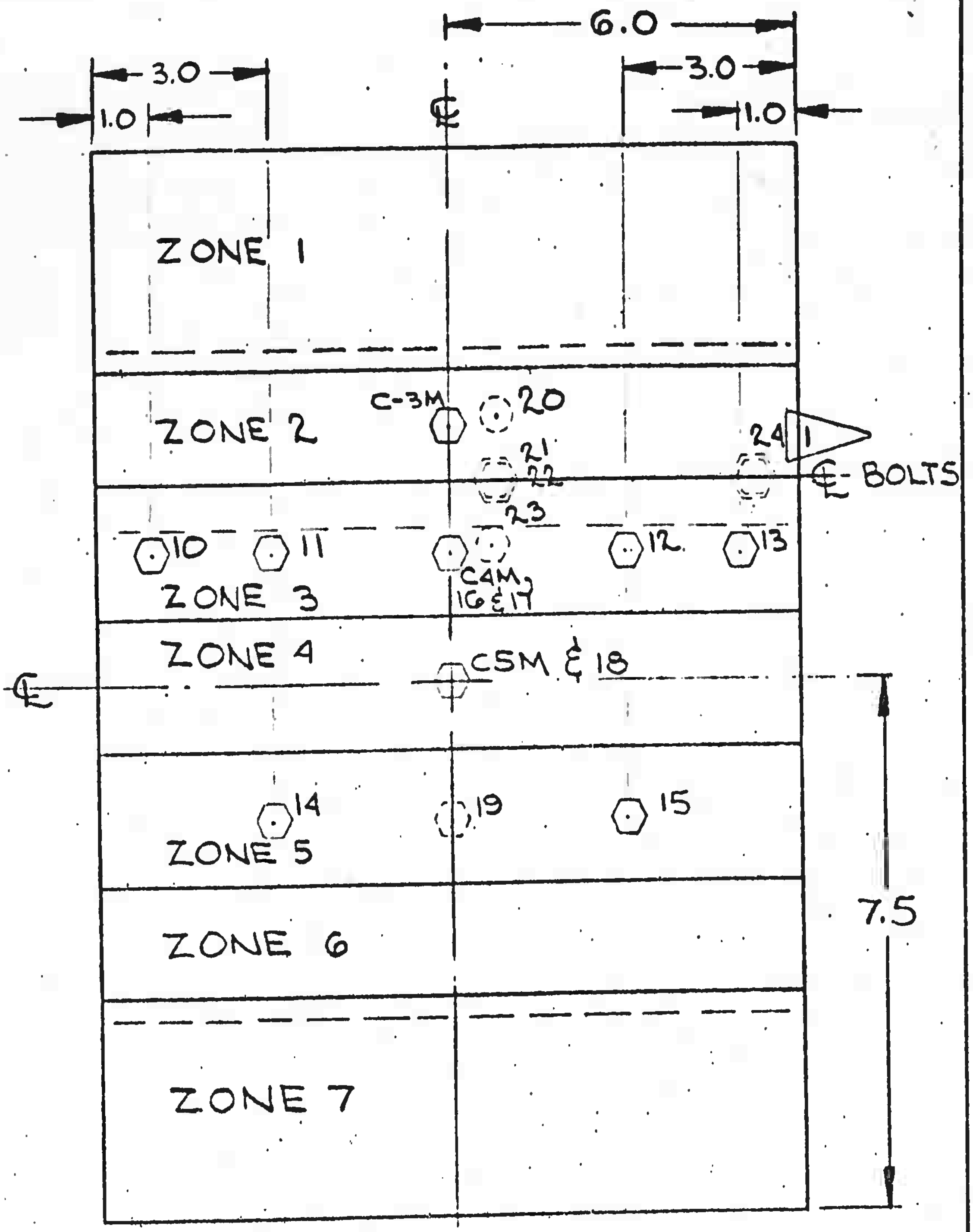


LAMP & ZONE LAYOUT
MONITOR THERMOCOUPLE LOCATIONS
25-20372-5 INSTALLATION

T.C. 24 WILL NOT BE MONITORED

See Fig. 3-6 for plan view

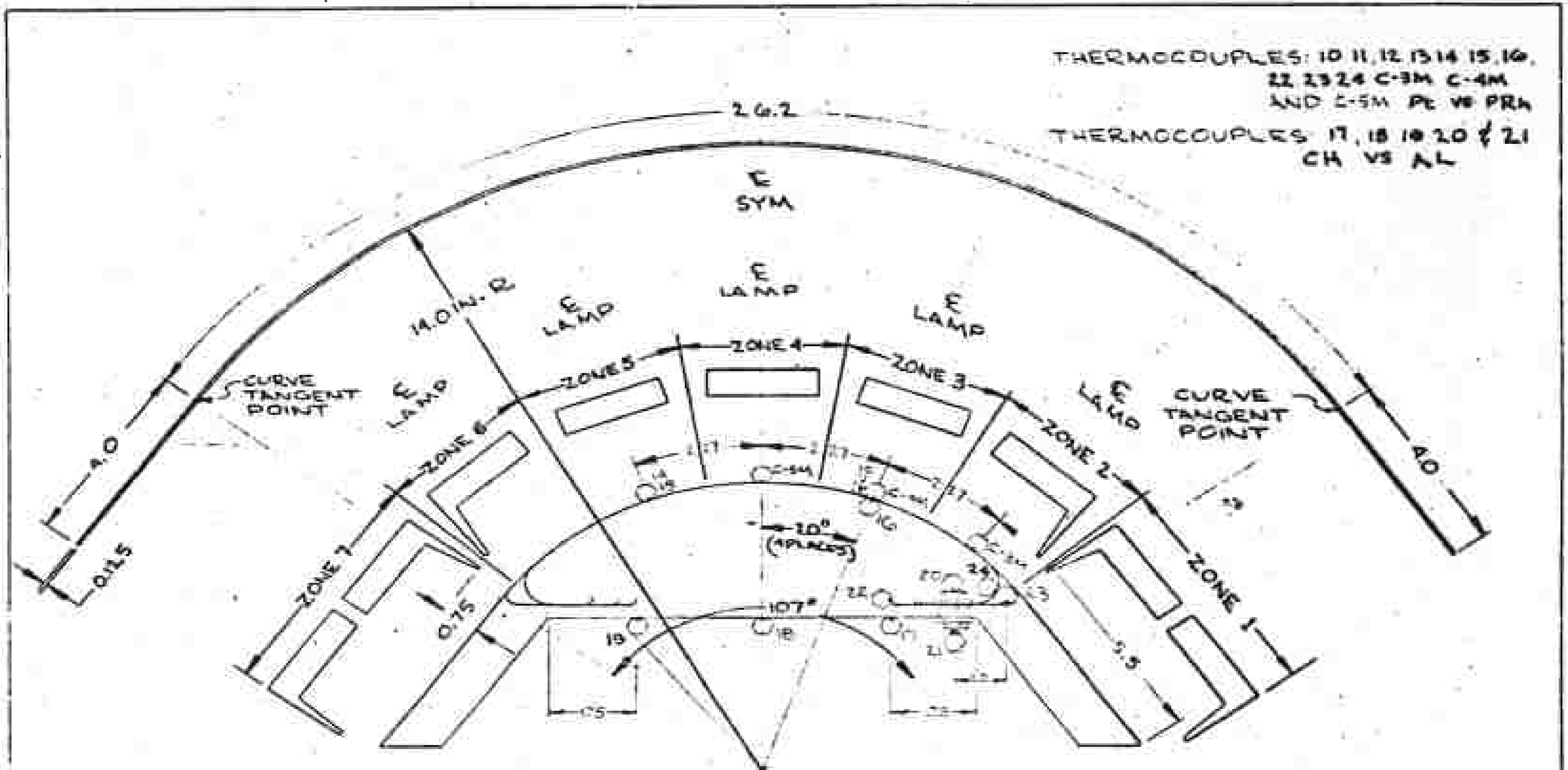
9-3-63



1 T.C. 24 WILL NOT BE MONITORED

Pt-Rh		CR-AL
10	16	17
11	20	18
12	23	19
13	C-3M	21
14	C-4M	22
15	C-5M	

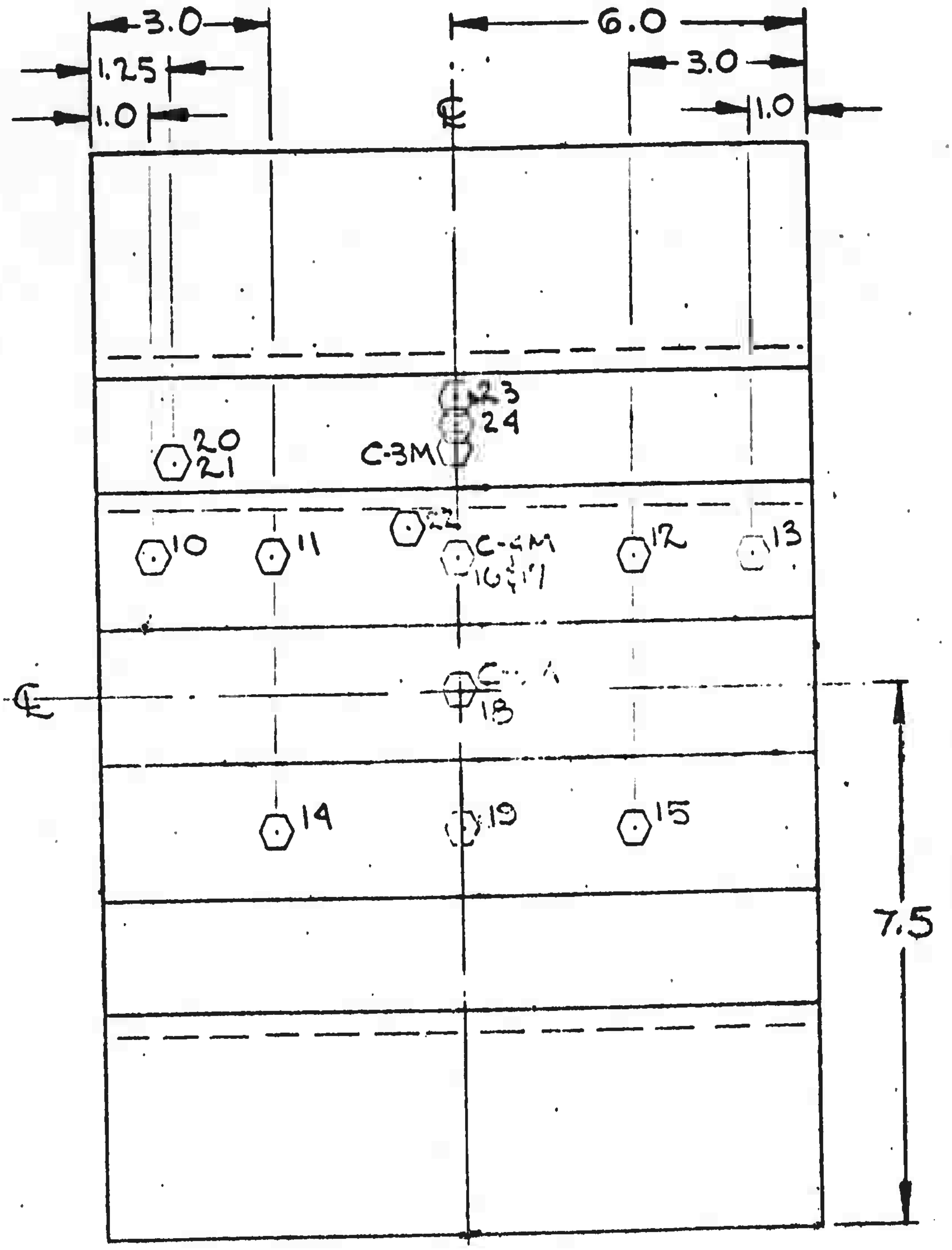
MONITOR THERMOCOUPLE LOCATIONS
25-20372 - 5 INSTALLATION



LAMP & ZONE LAYOUT
MONITOR THERMOCOUPLE LOCATIONS
25-20367-3 INSTALLATION

See Fig. 3-8 for plan view

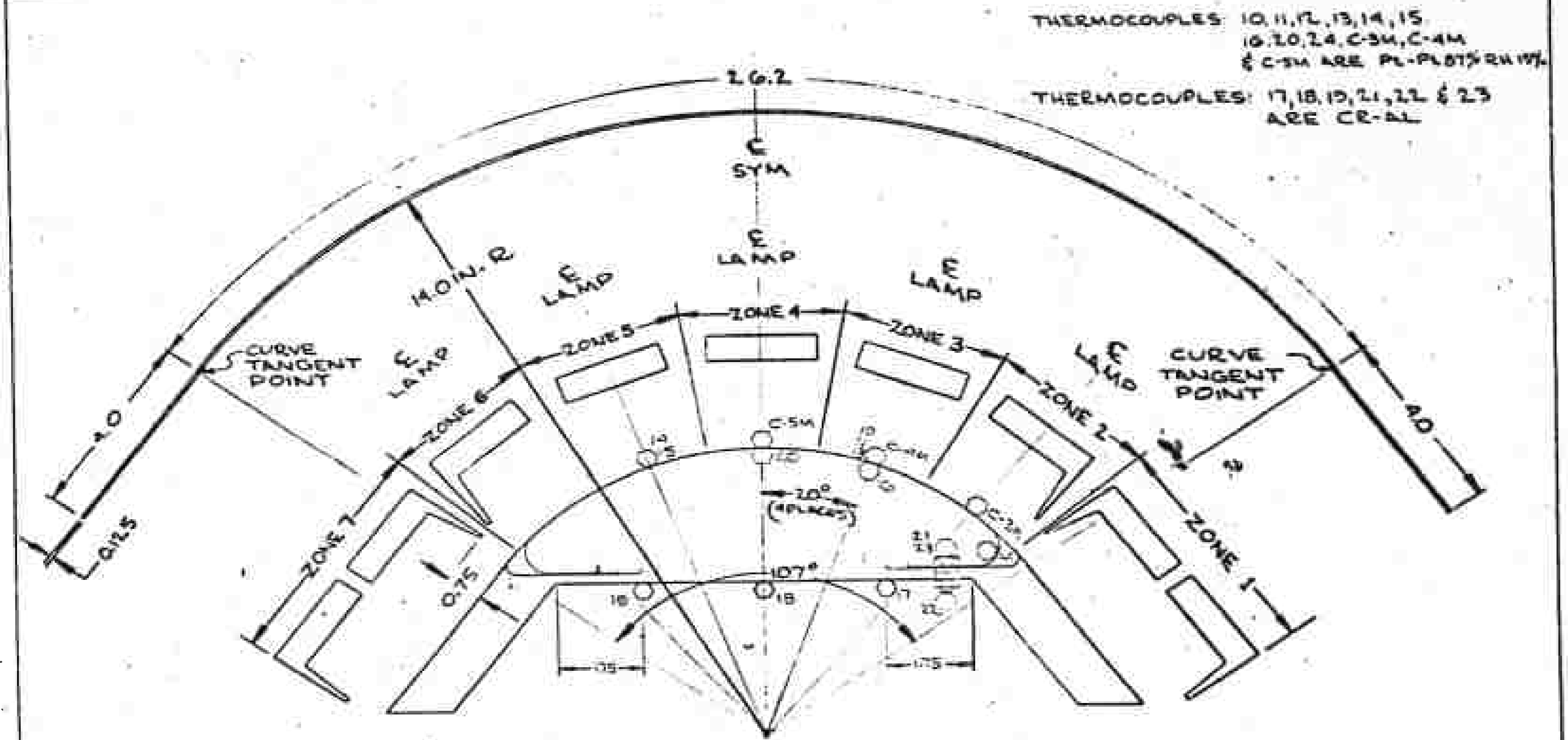
9-3-63



Pt vs. PRh	
10	22
11	23
12	24
13	C-3m
14	C-4m
15	C-5m
16	

CH vs. AL
17
18
19
20
21

MONITOR THERMOCOUPLE LOCATIONS
25-20367 - 3 INSTALLATION

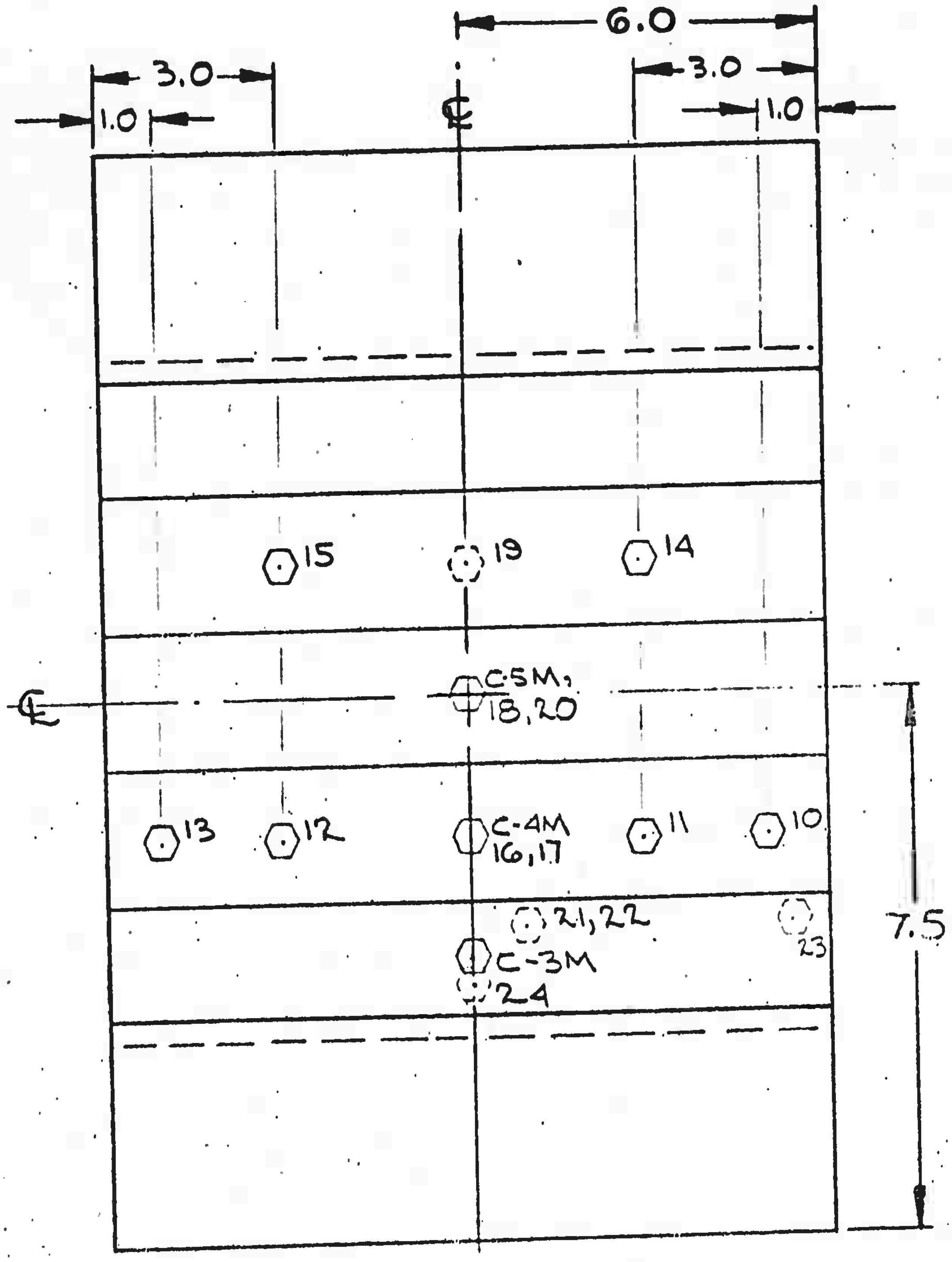


LAMP & ZONE LAYOUT
MONITOR THERMOCOUPLE LOCATIONS
25-20378 -6 INSTALLATION

See Fig. 3-10 for plan view

9-3-63

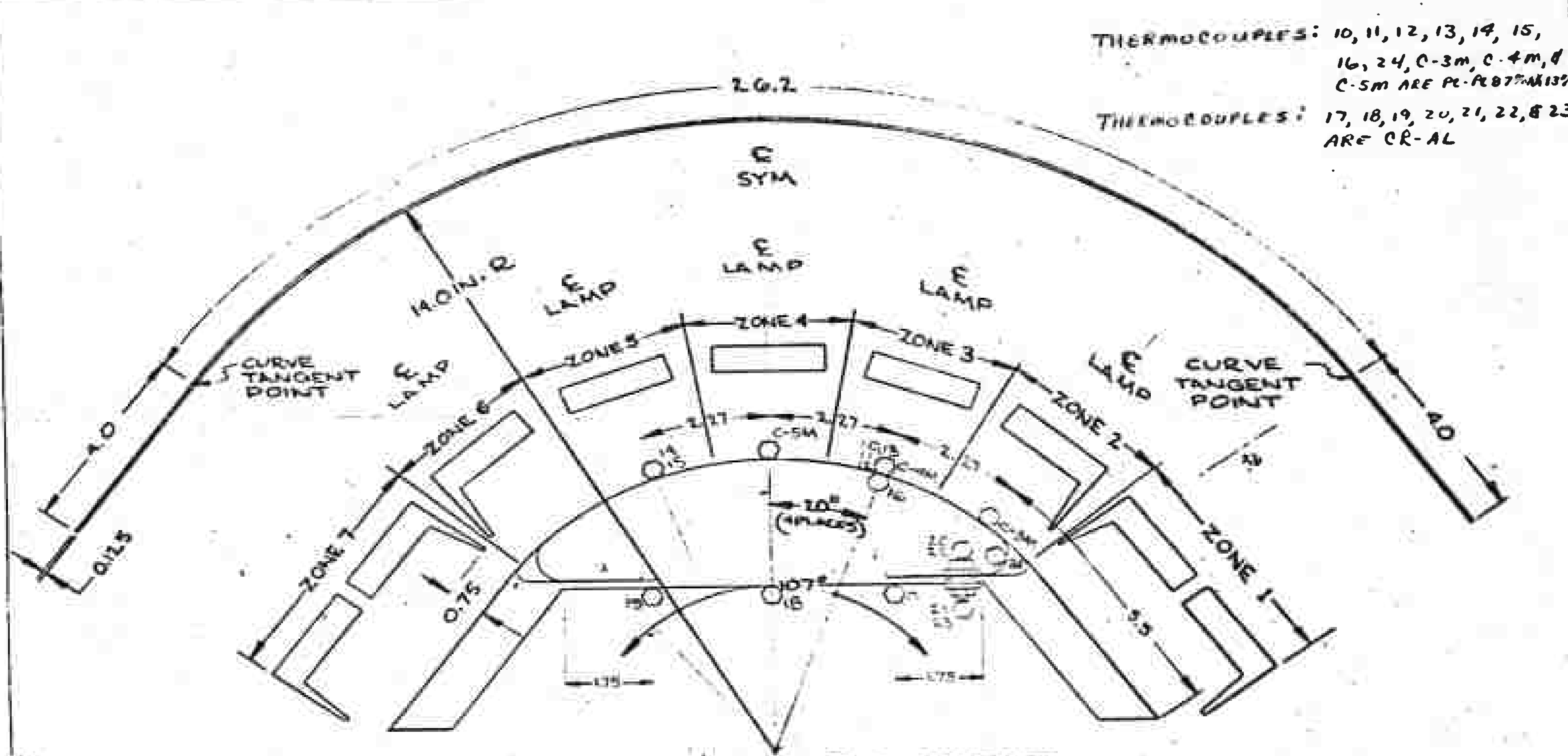
#2 6



Pt-Pt 87% RH 13%		CR-AL
10	16	17
11	20	18
12	24	19
13	C-3m	21
14	C-4m	22
15	C-5m	23

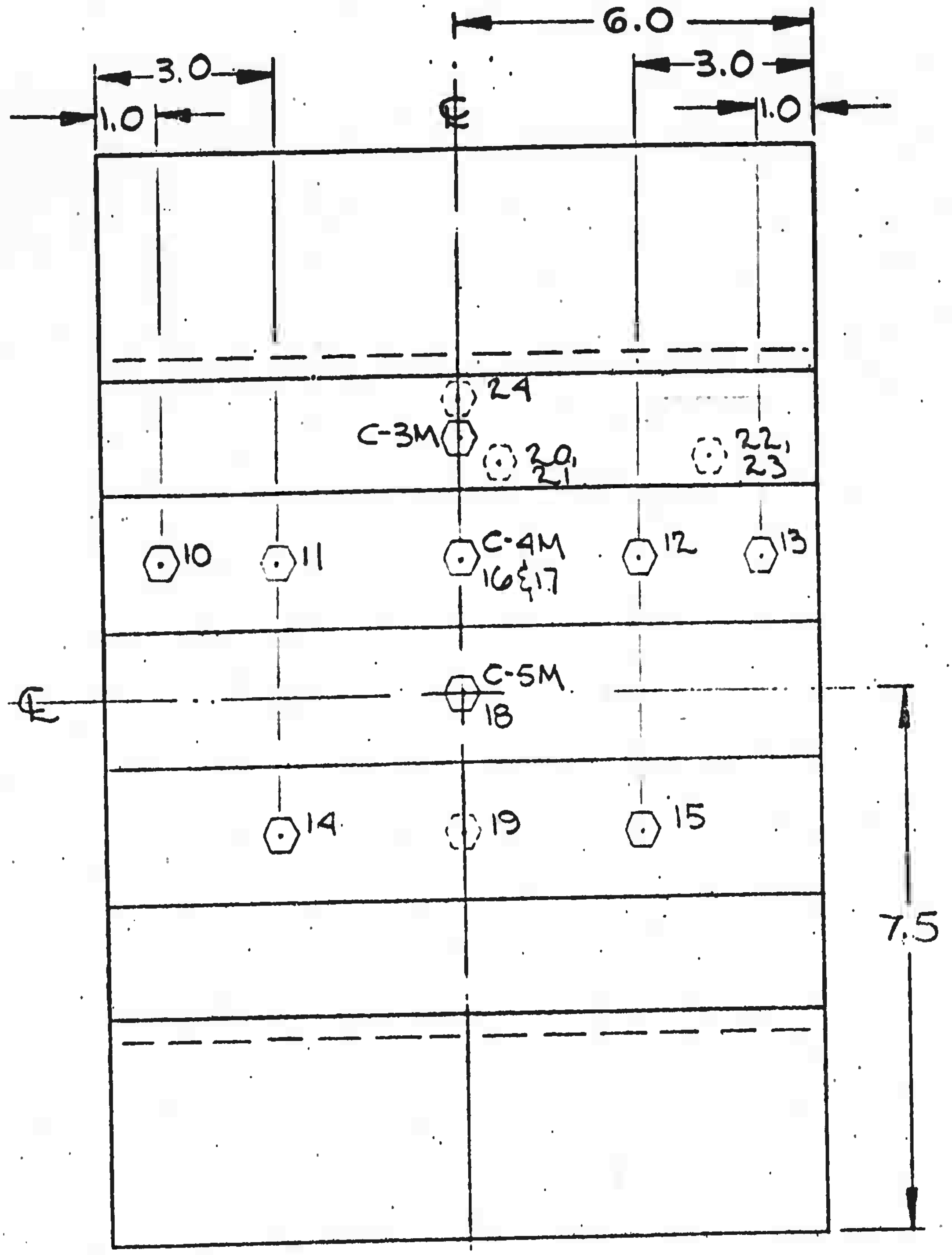
MONITOR THERMOCOUPLE LOCATIONS
25-20378 – 6 INSTALLATION

9-3-63



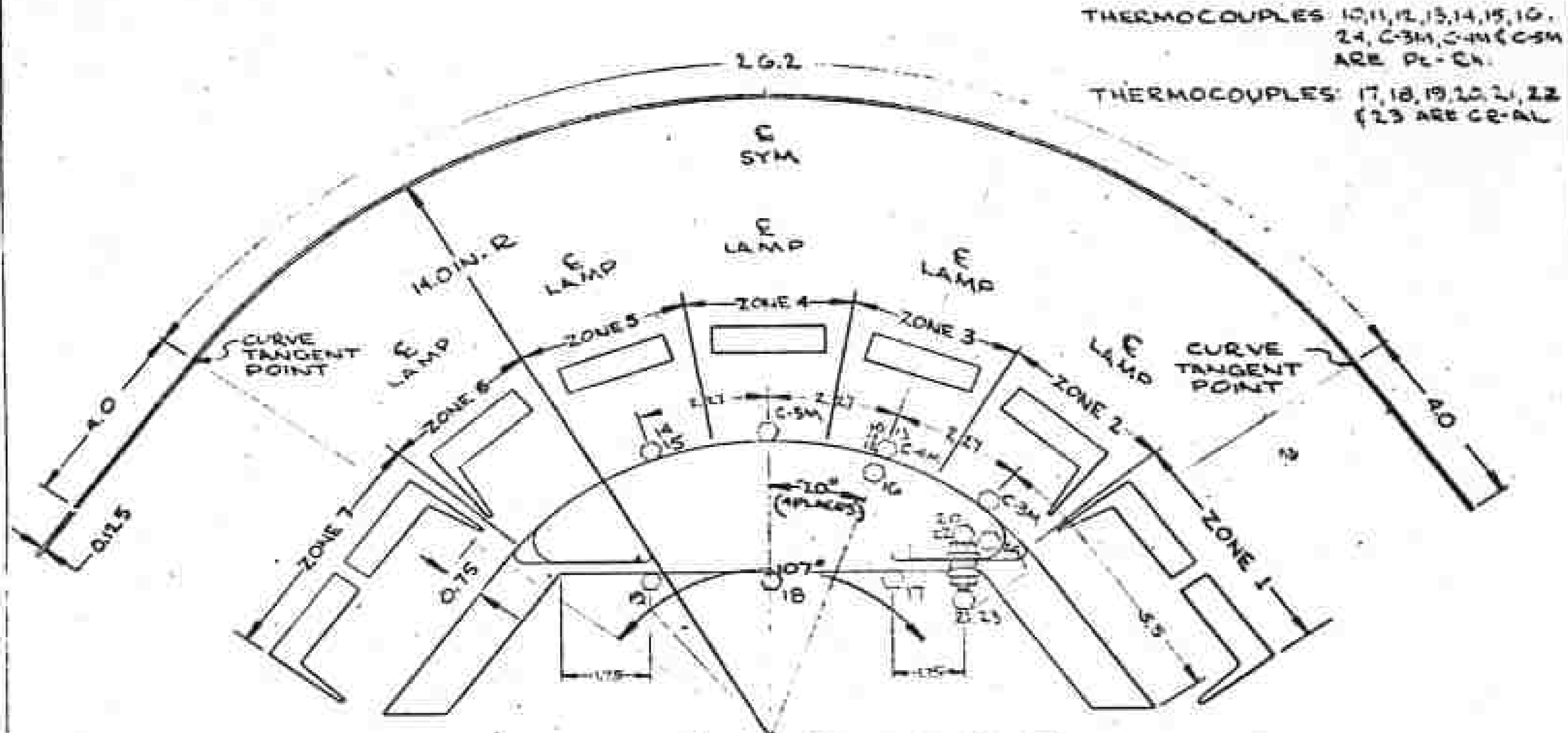
LAMP & ZONE LAYOUT
MONITOR THERMOCOUPLE LOCATIONS
25-20341 -1 INSTALLATION

See Fig. 3-12 for plan view



Pt-Pt87% Rh13%		CR-AL
10	16	17
11	24	18
12	C-3m	19
13	C-4m	20
14	C-5m	21
15		22
		23

MONITOR THERMOCOUPLE LOCATIONS
25-20341 -1 INSTALLATION

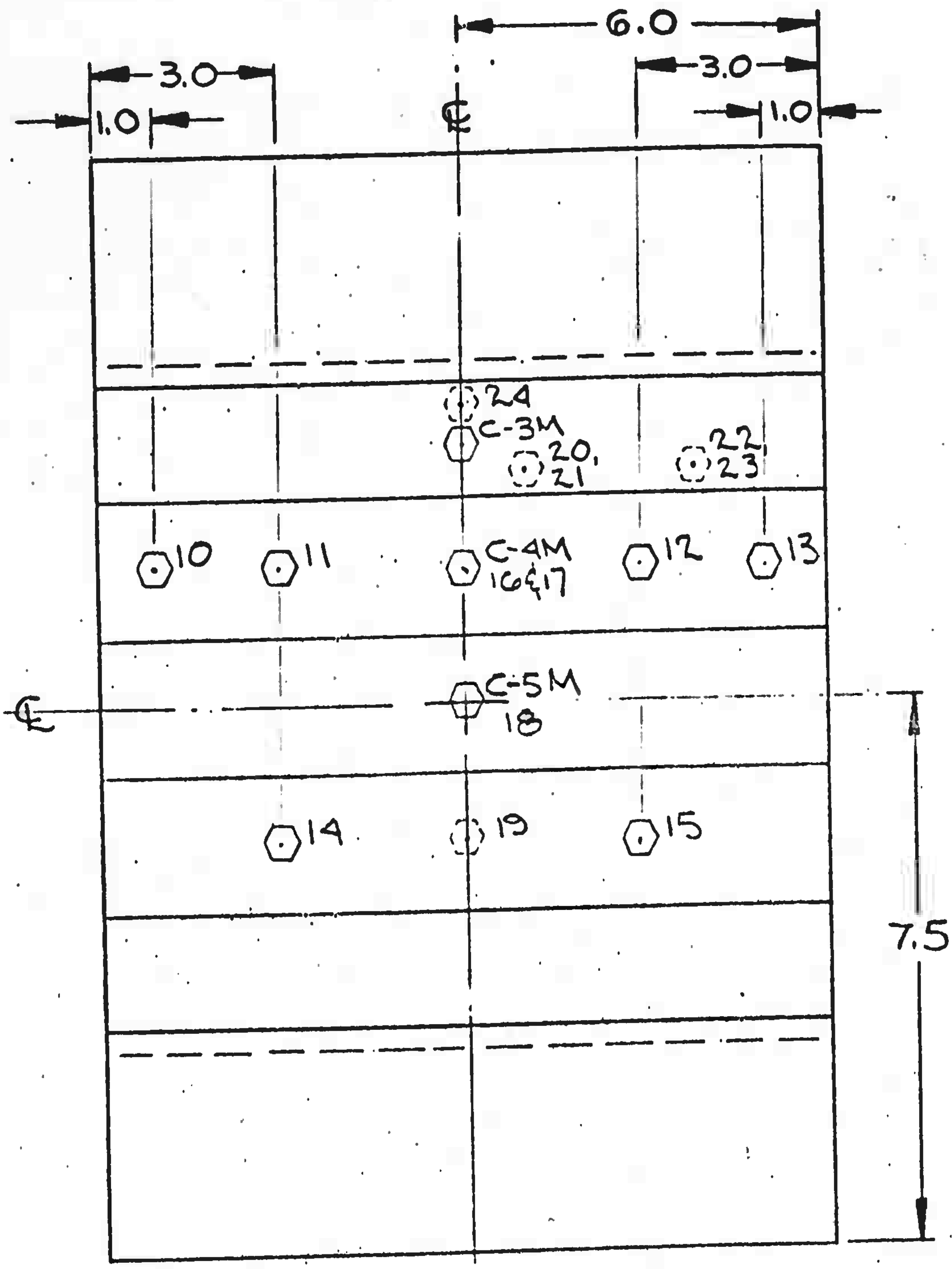


LAMP & ZONE LAYOUT
MONITOR THERMOCOUPLE LOCATIONS
25-20376-2 INSTALLATION

See Fig. 3-14 for plan view

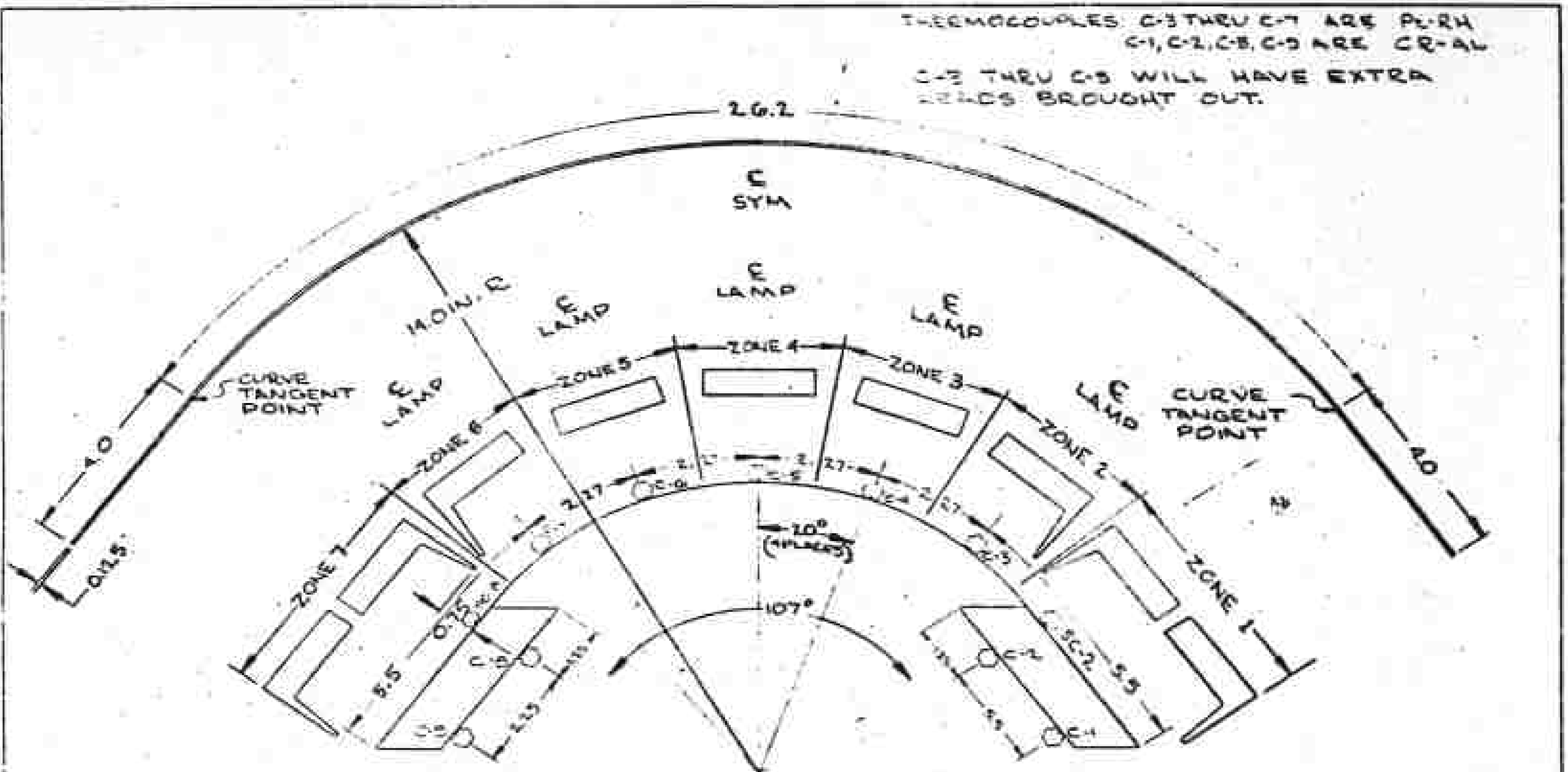
9-3-63

FIG. 3-13



Pt-Rh		CR-AL
10	16	17
11	24	18
12	C-3m	19
13	C-4m	20
14	C-5m	21
15		22
		23

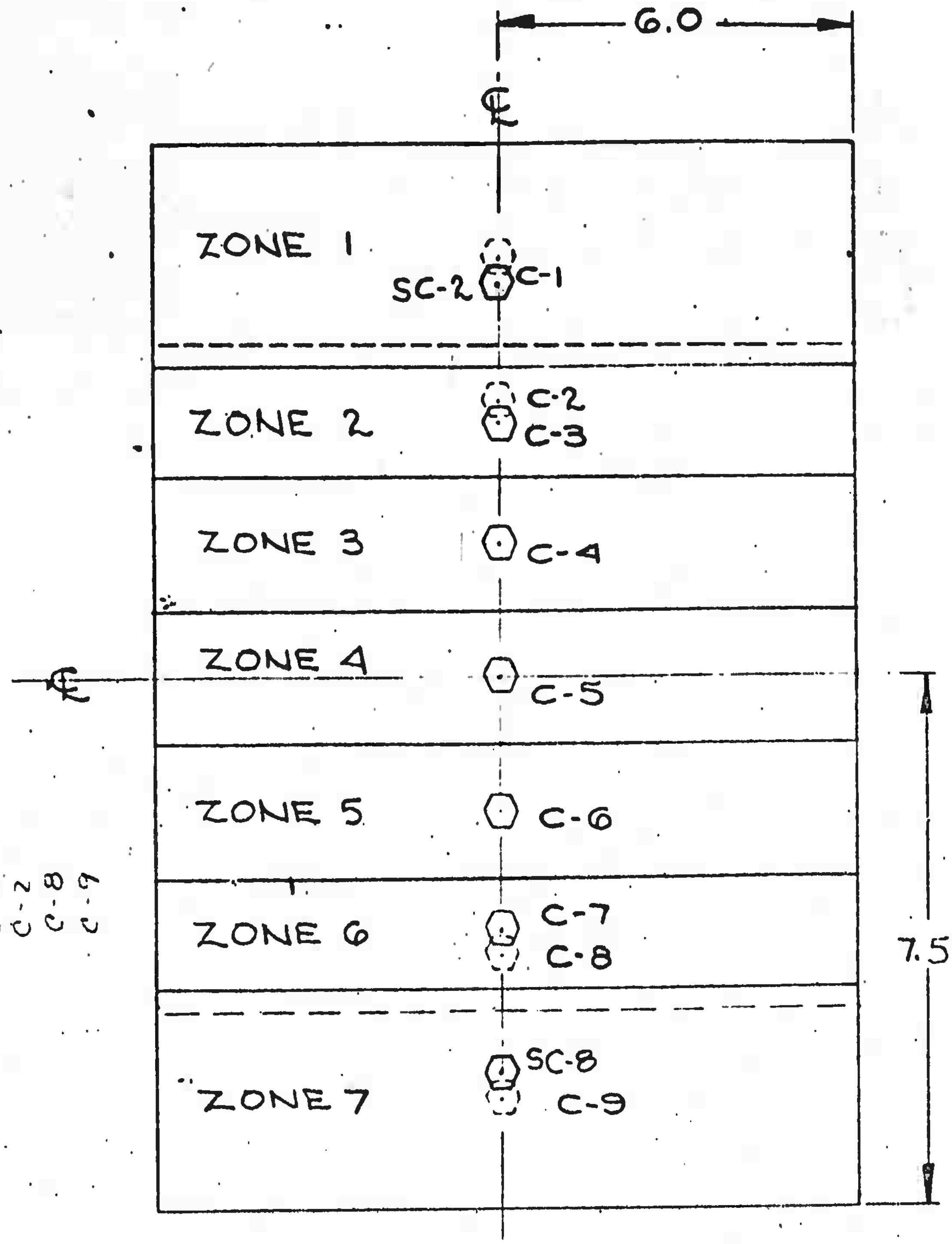
MONITOR THERMOCOUPLE LOCATIONS
25-20376 - 2 INSTALLATION



LAMP ℄ ZONE LAYOUT
CONTROL THERMOCOUPLES

See Fig. 3-16 for plan view

9-3-63



CK-AL c-1 c-2 c-8 c-9

Pt-Rh c-3 c-4 c-5 c-6 c-7

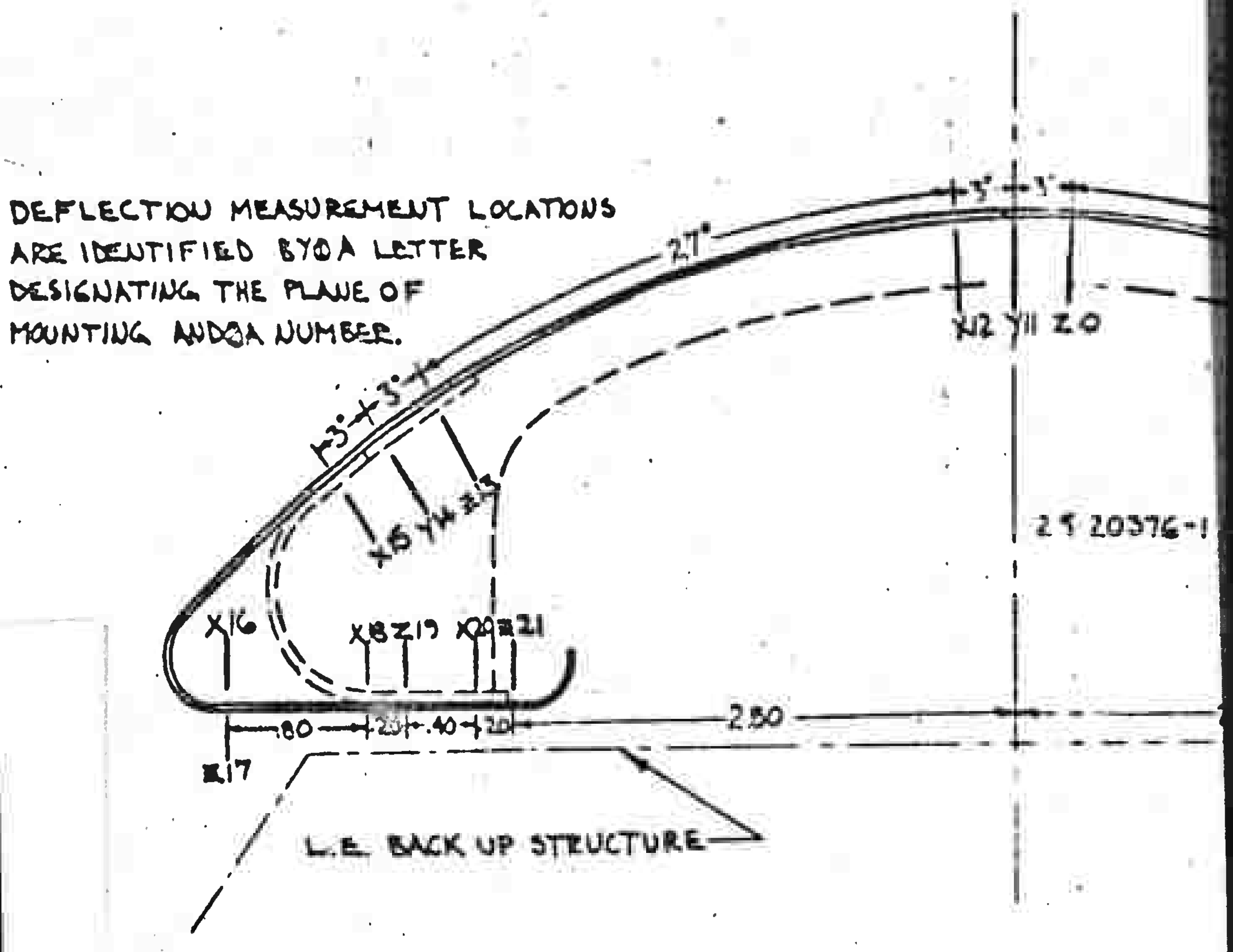
THERMOCOUPLES C-1 THROUGH C-9 ARE CONTROL

ZONE LAYOUT & CONTROL THERMOCOUPLE LOCATIONS

TABLE 1

LEADING EDGE ASSEMBLY NO.	DIMENSION x	DIMENSION y	DIMENSION z	LOCATIONS NOT USED	TOTAL NU[illegible] OF LOCATI[illegible]
25-20372-1	0	3.00	6.00	—	21
25-20378-1	0.75	3.00	6.00	—	21
25-20367-1	0.80	3.00	6.00	—	21
25-20376-1	0 (ON FLANGE)	3.00	6.35 (ON FLANGE)	X2, Z3, X4, X7, Y8, Z9, Z13, Y14, X15, X18, Z19, X20	9
25-20341-1	0	3.00	6.00	—	21

DEFLECTION MEASUREMENT LOCATIONS ARE IDENTIFIED BY A LETTER DESIGNATING THE PLANE OF MOUNTING AND A NUMBER.



1

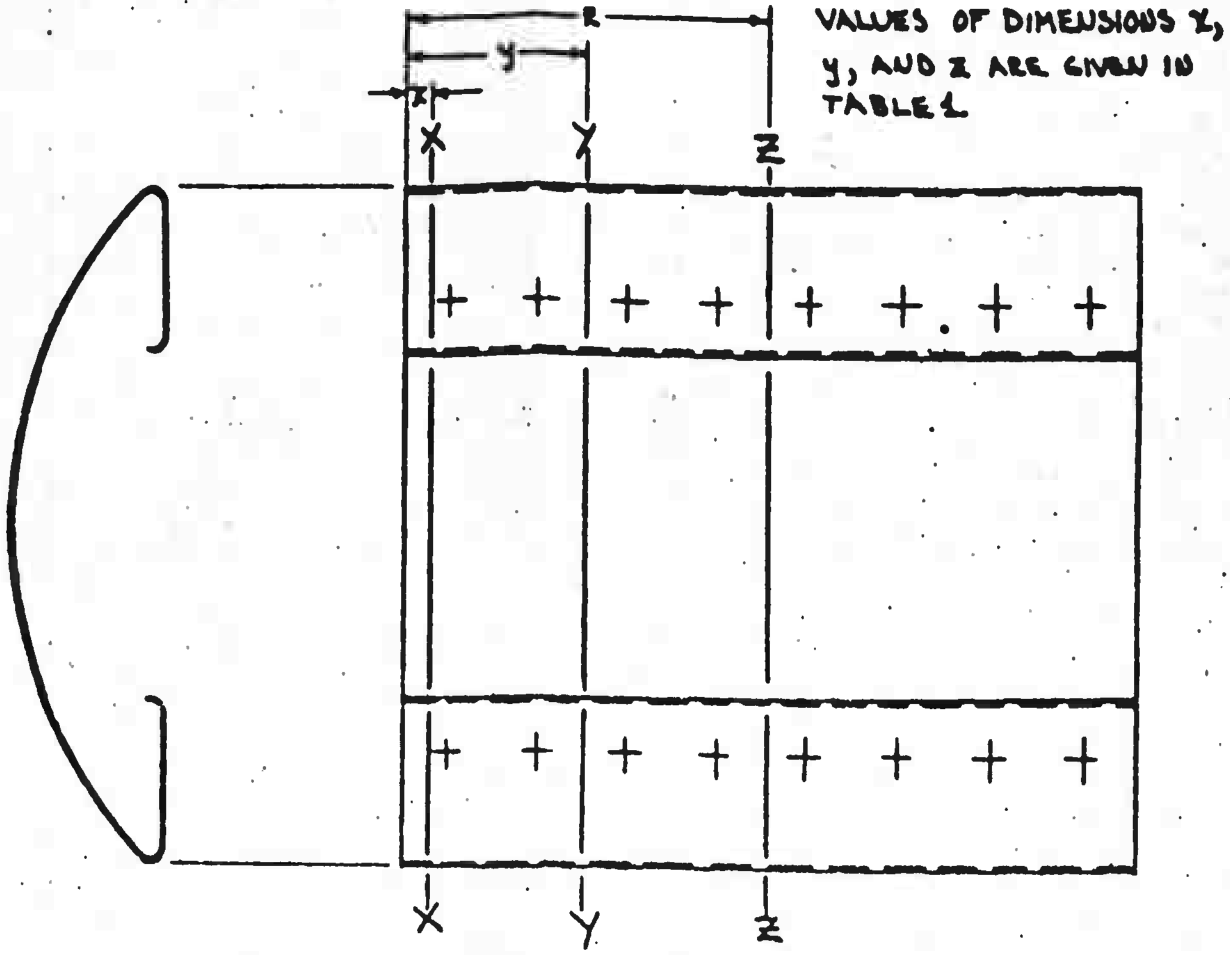
EWA 5-617 LEADING EDGE CROSS SECT[illegible]

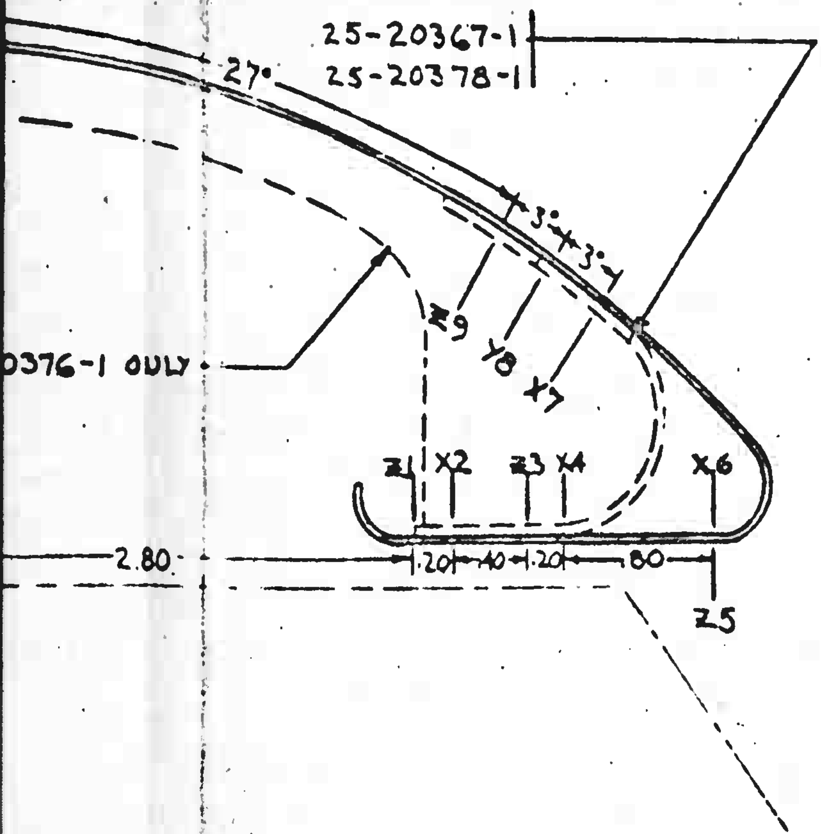
REVISED 9-3-63

BAC 4339

37

AL NUMBER LOCATIONS
21
21
21
9
21



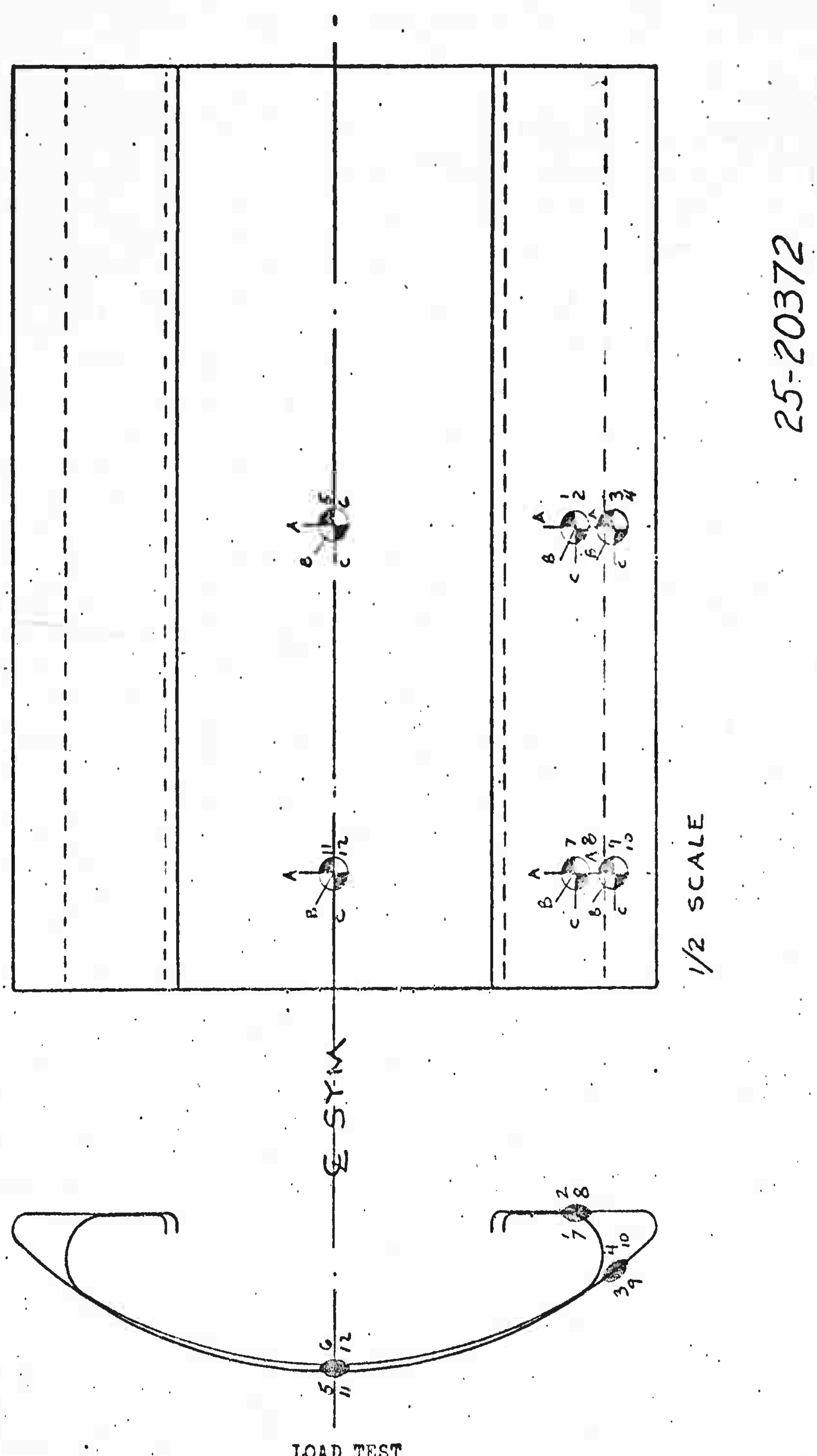


SECTION (FULL SIZE)

PHOTOGRAPHIC DEFLECTION MEASUREMENT LOCATIONS
EWA 5-617 LT-3

2

FIGURE 3-17

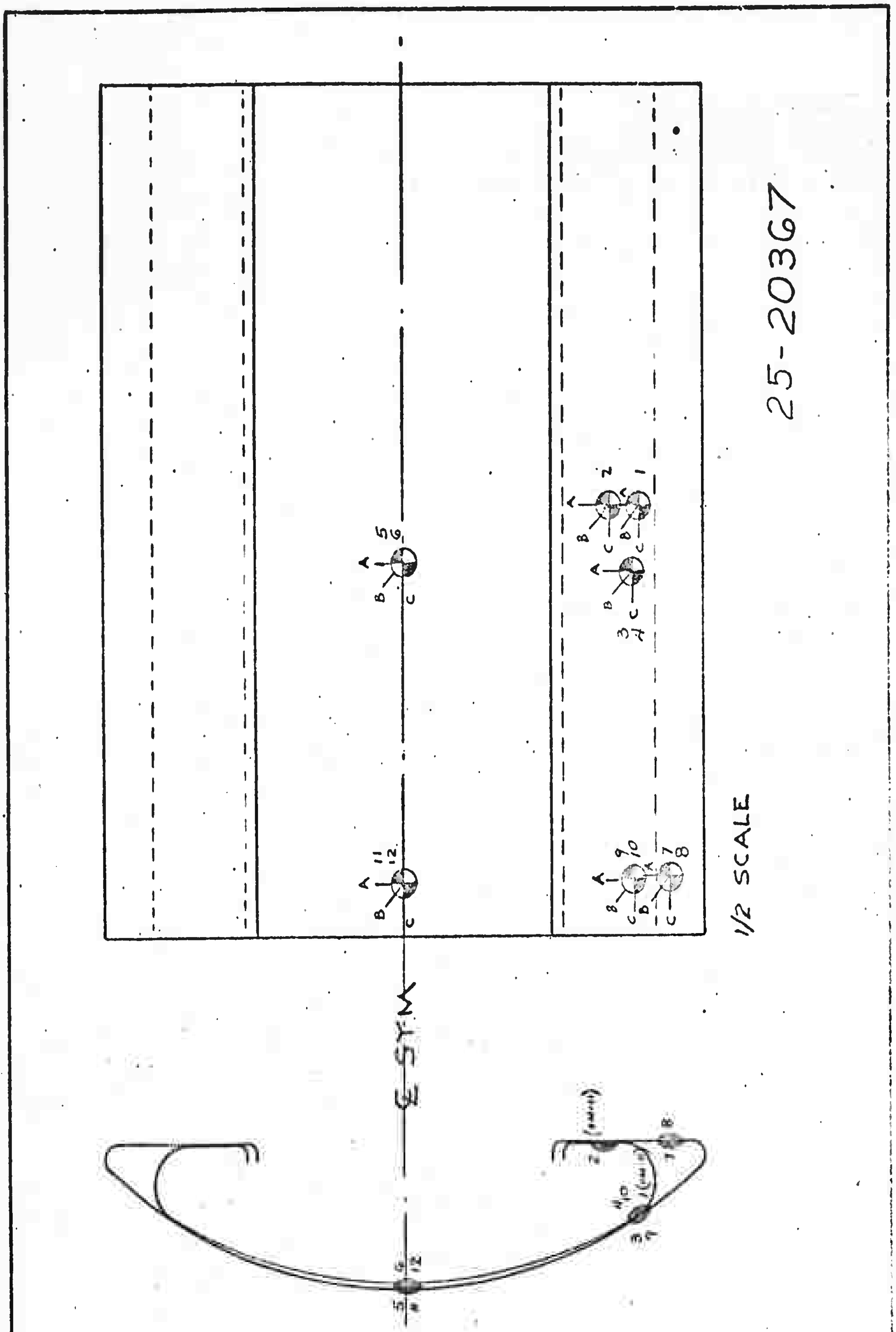


LOAD TEST
STRAIN GAGE INSTRUMENTATION
25-20372

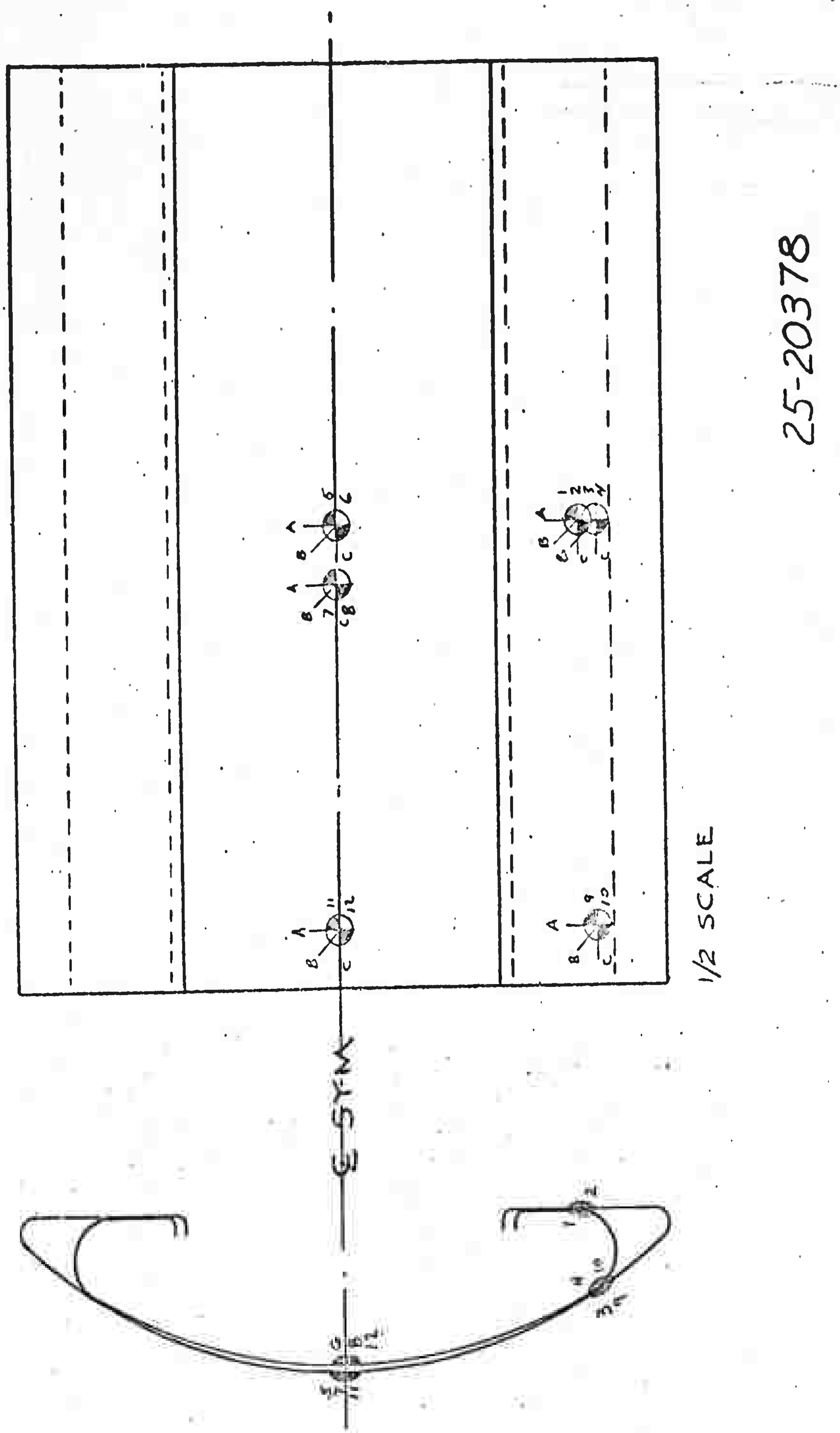
ATTACHMENT 2

U3-4071-1000

9-3-63



LOAD TEST
STRAIN GAGE INSTRUMENTATION



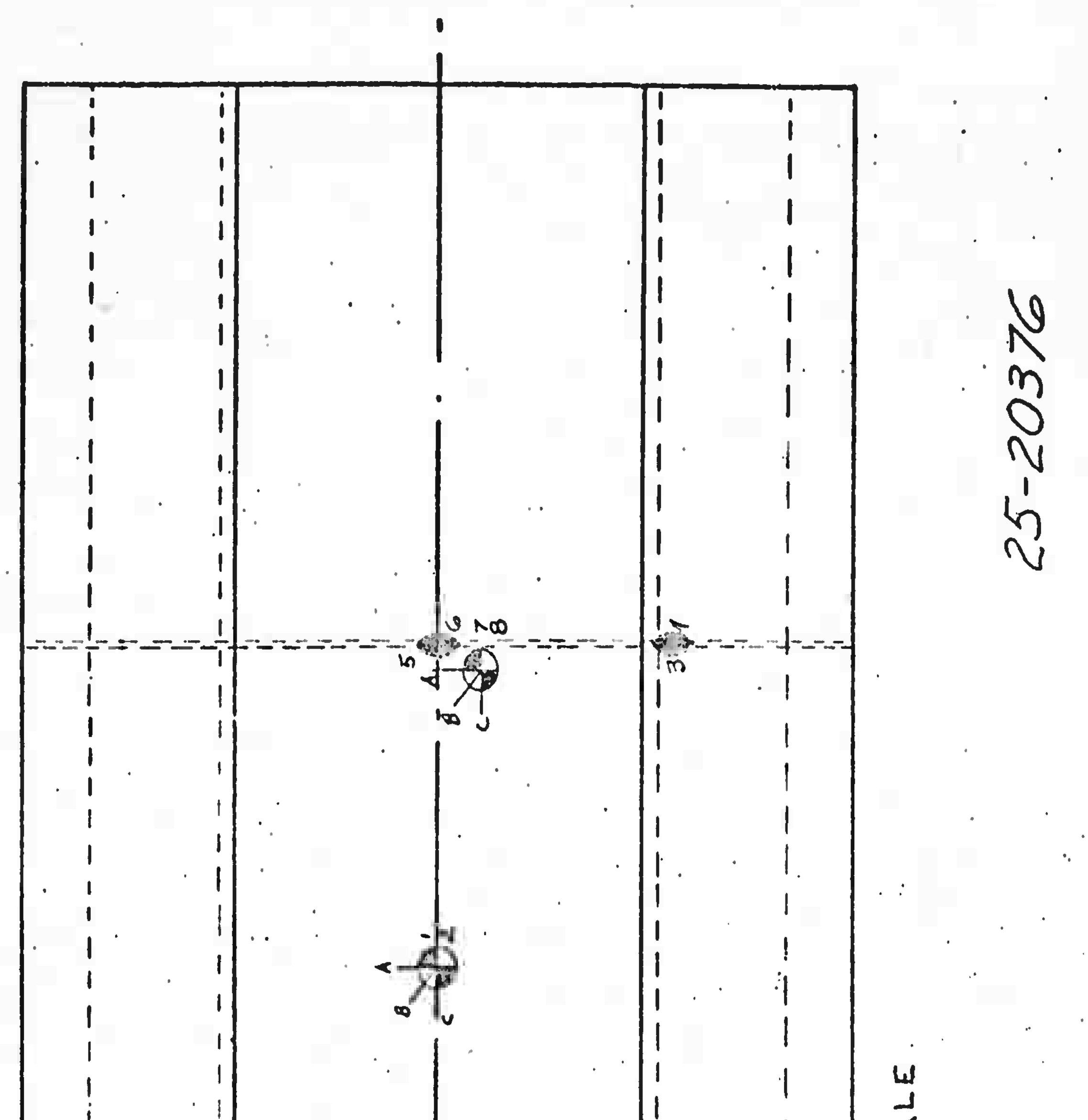
LOAD TEST
STRAIN GAGE INSTRUMENTATION

ATTACHMENT A

U3-4071-1000

25-20378

9-3-63

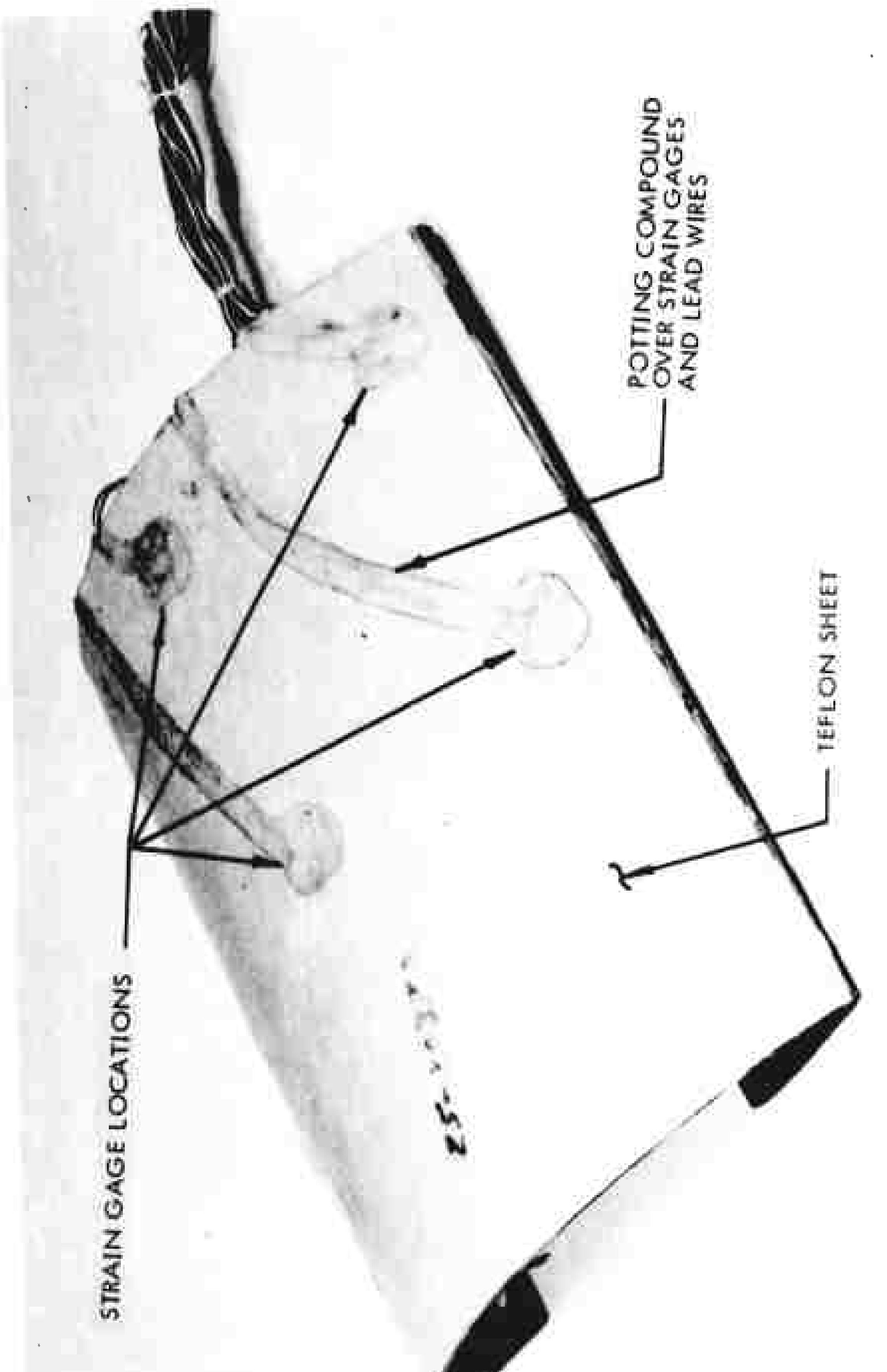


LOAD TEST
STRAIN GAGE INSTRUMENTATION
25-20376

ATTACHMENT 3

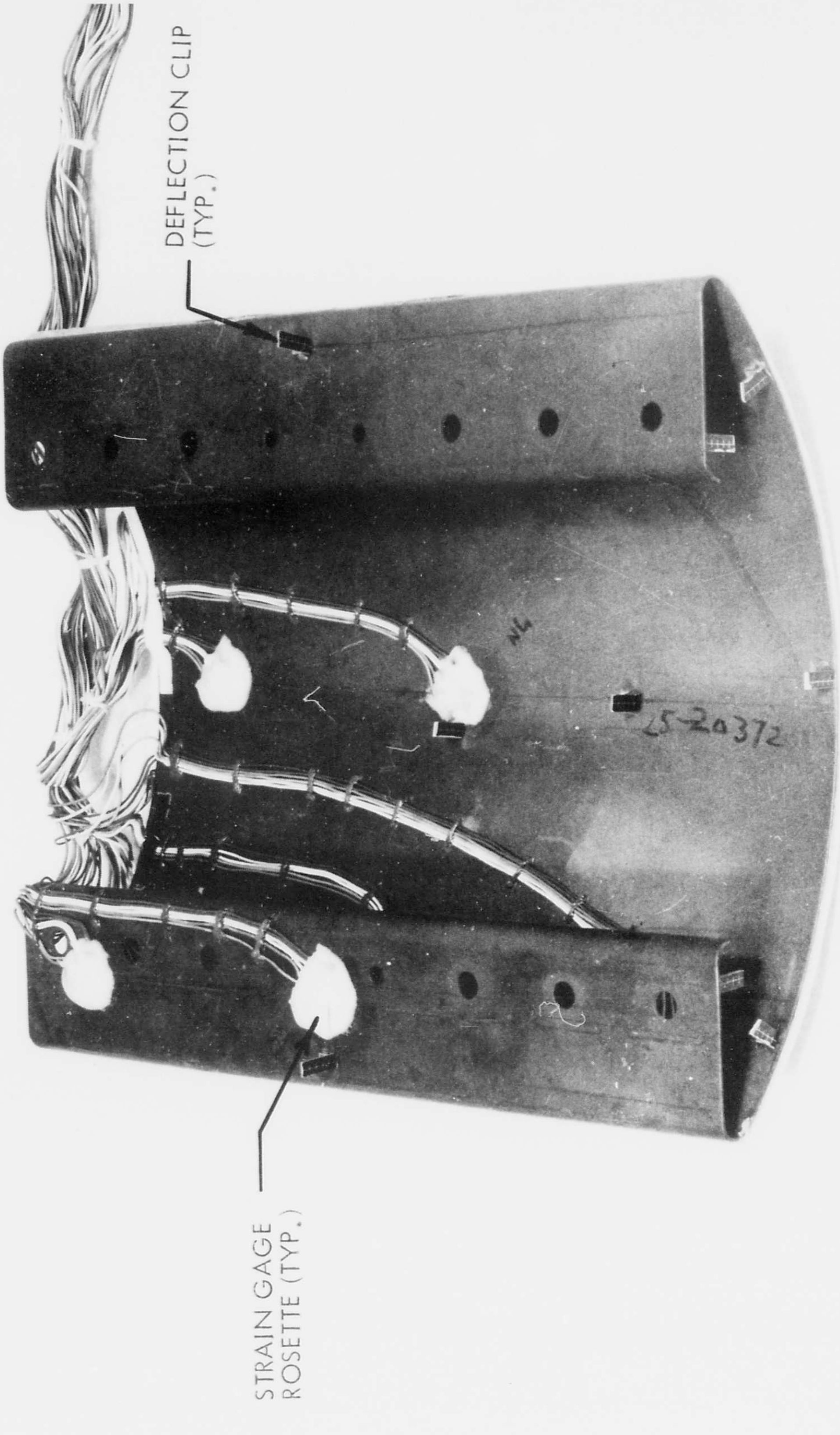
LS-I LEADING EDGE #25-20372 BEFORE TESTING - TOP VIEW 1-7-62

2A95729

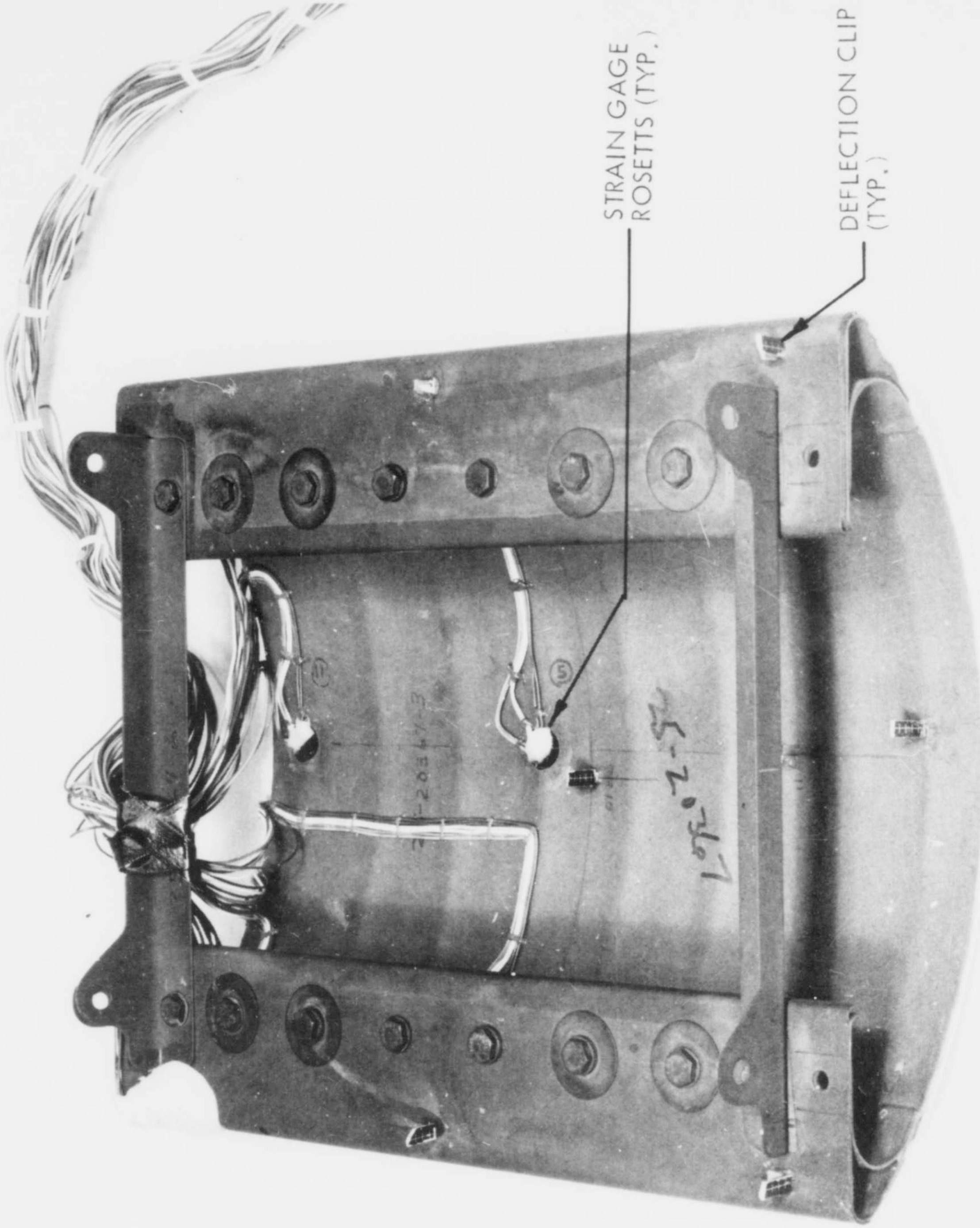


See Fig. 3-23 for Bottom View

STRAIN GAGE INSTRUMENTATION
25-20372-I BEFORE LOAD TEST



25-20372-1 BEFORE LOAD TEST



See Fig. 3-25 for Top View

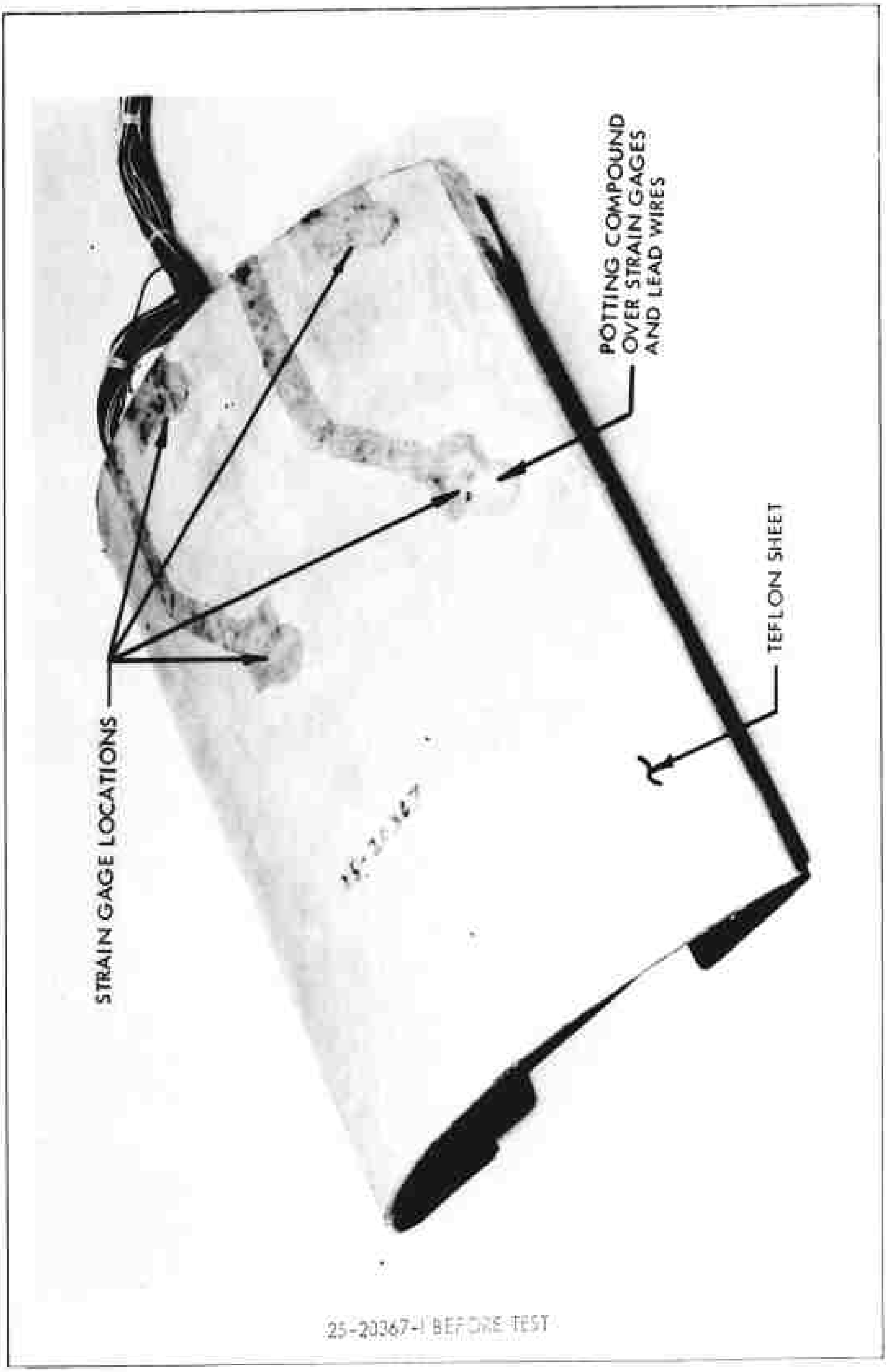
DS-I LEADING EDGE #25-20367 BEFORE TESTING - BACK VIEW 1-7-62

2A95723

25-20367-I BEFORE LOAD TEST

DS-I LEADING EDGE #25-20367 BEFORE TESTING - FRONT VIEW 1-7-62

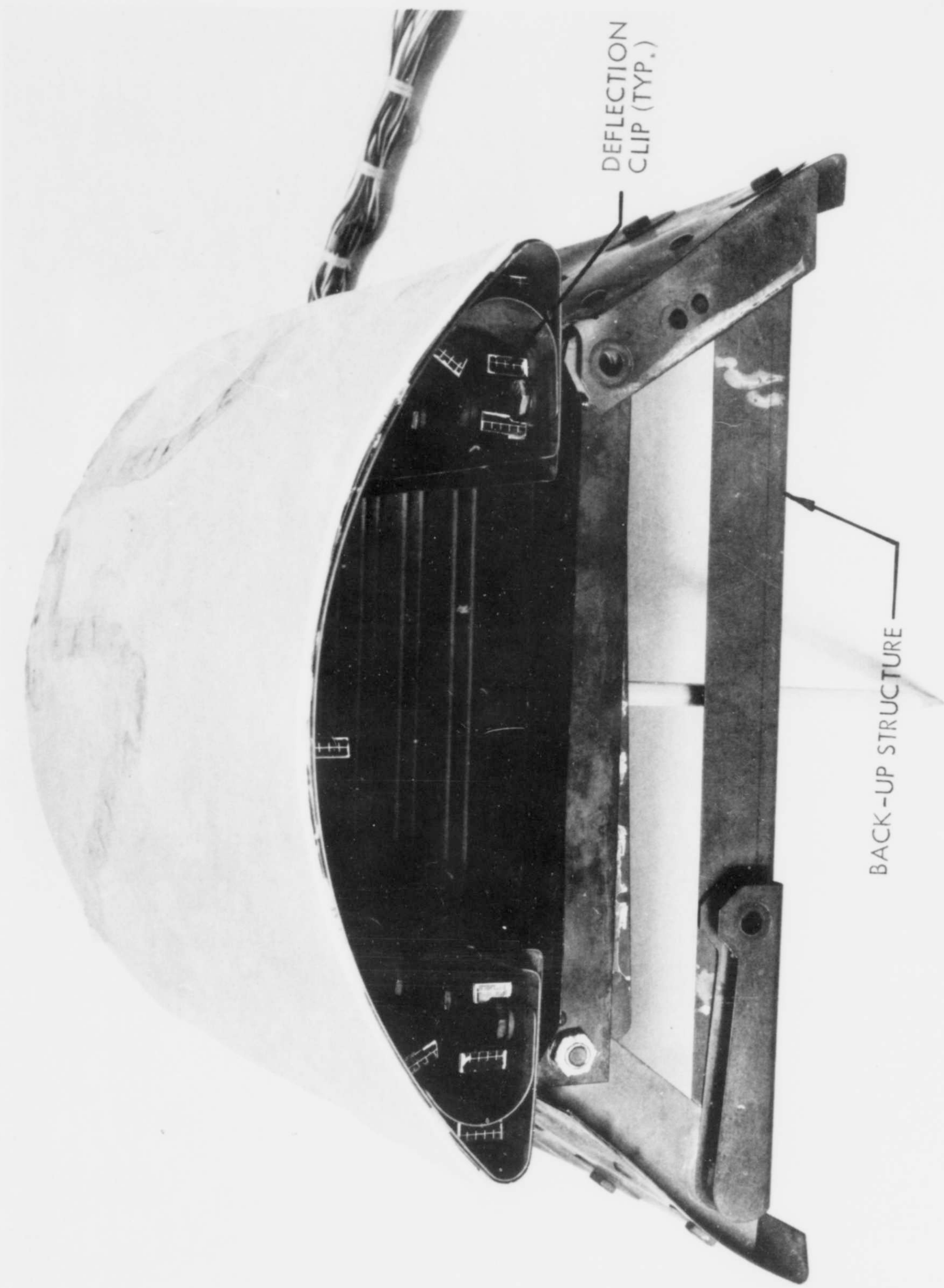
2A95724



U3-4071-1000 (was BAC 1546-L-R3)

DS-I LEADING EDGE - BEFORE TESTING
END VIEW
1-7-62

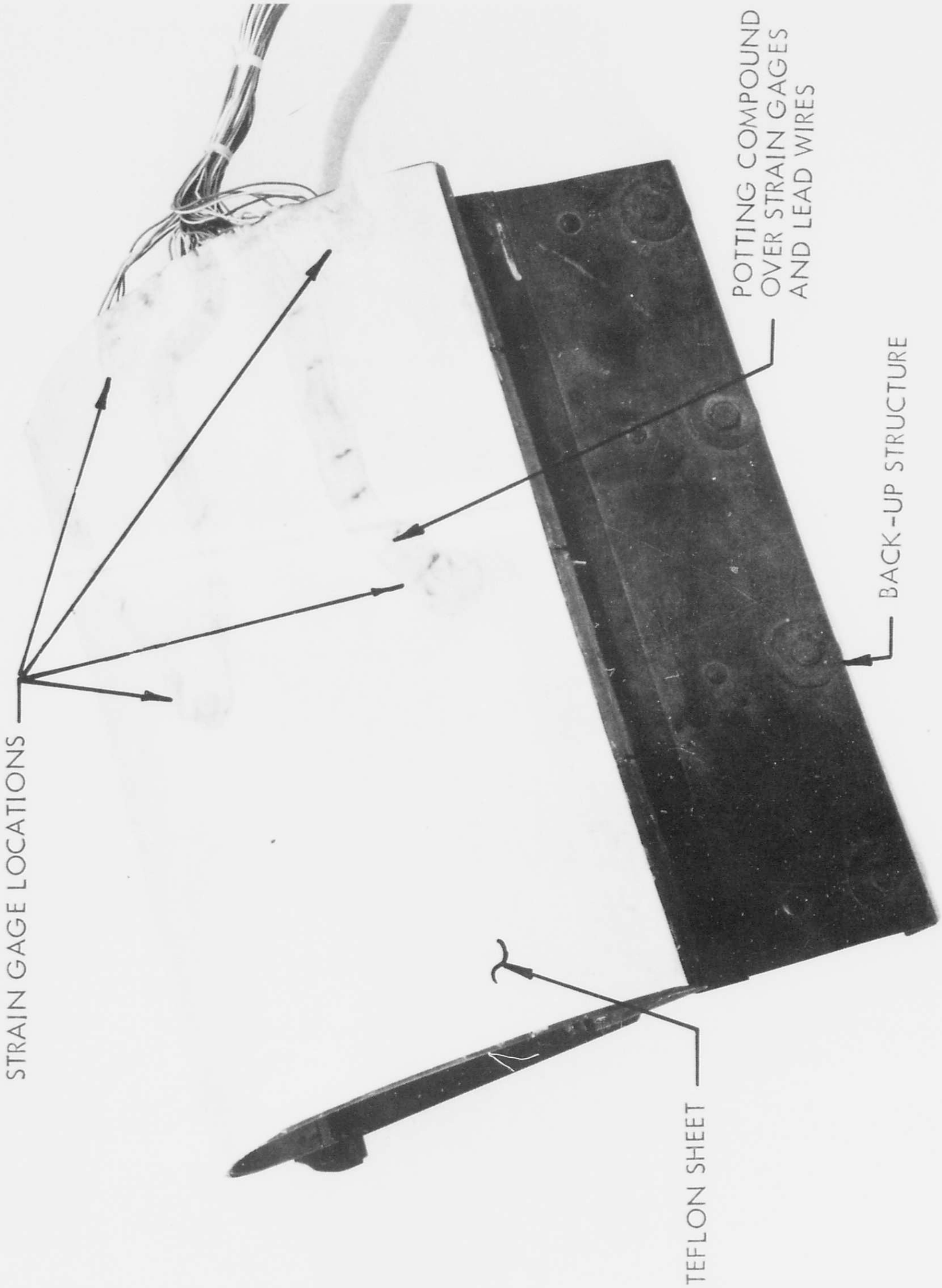
2A95725



25-20378 BEFORE LOAD TEST

DS-I LEADING EDGE - BEFORE TESTING 1-7-62
TOP VIEW

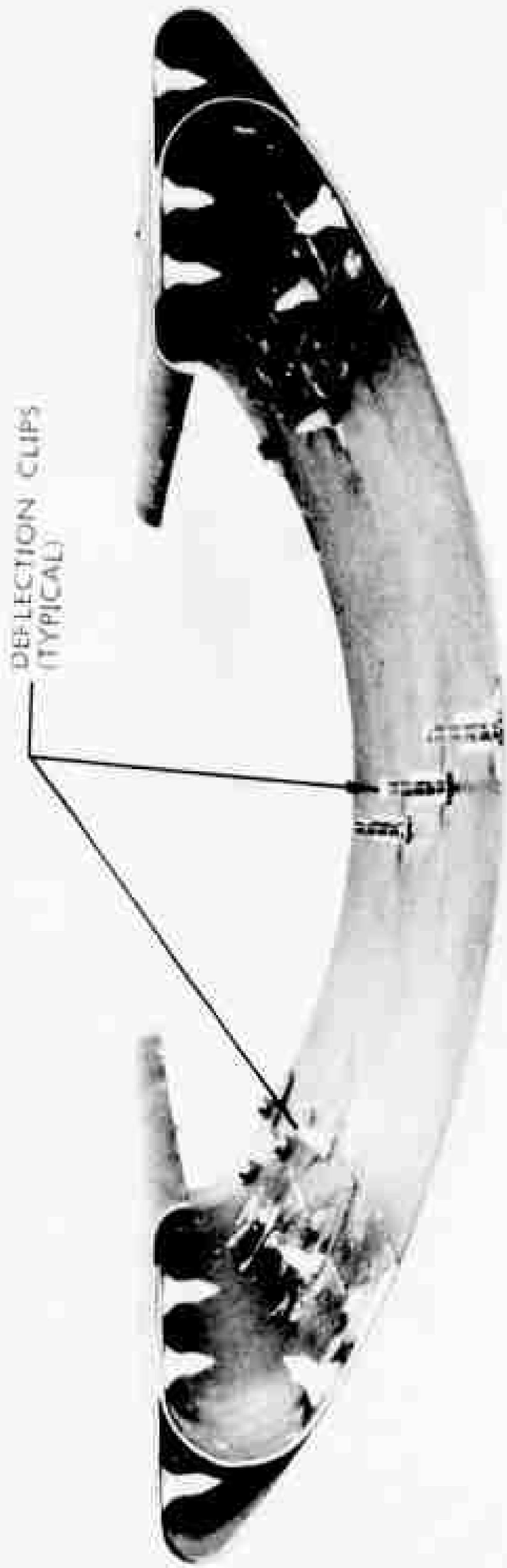
2A95726



25-20378 BEFORE LOAD TEST

DS-I LEADING EDGE SPEC. 25-20341 - 2-27-62 2A102438

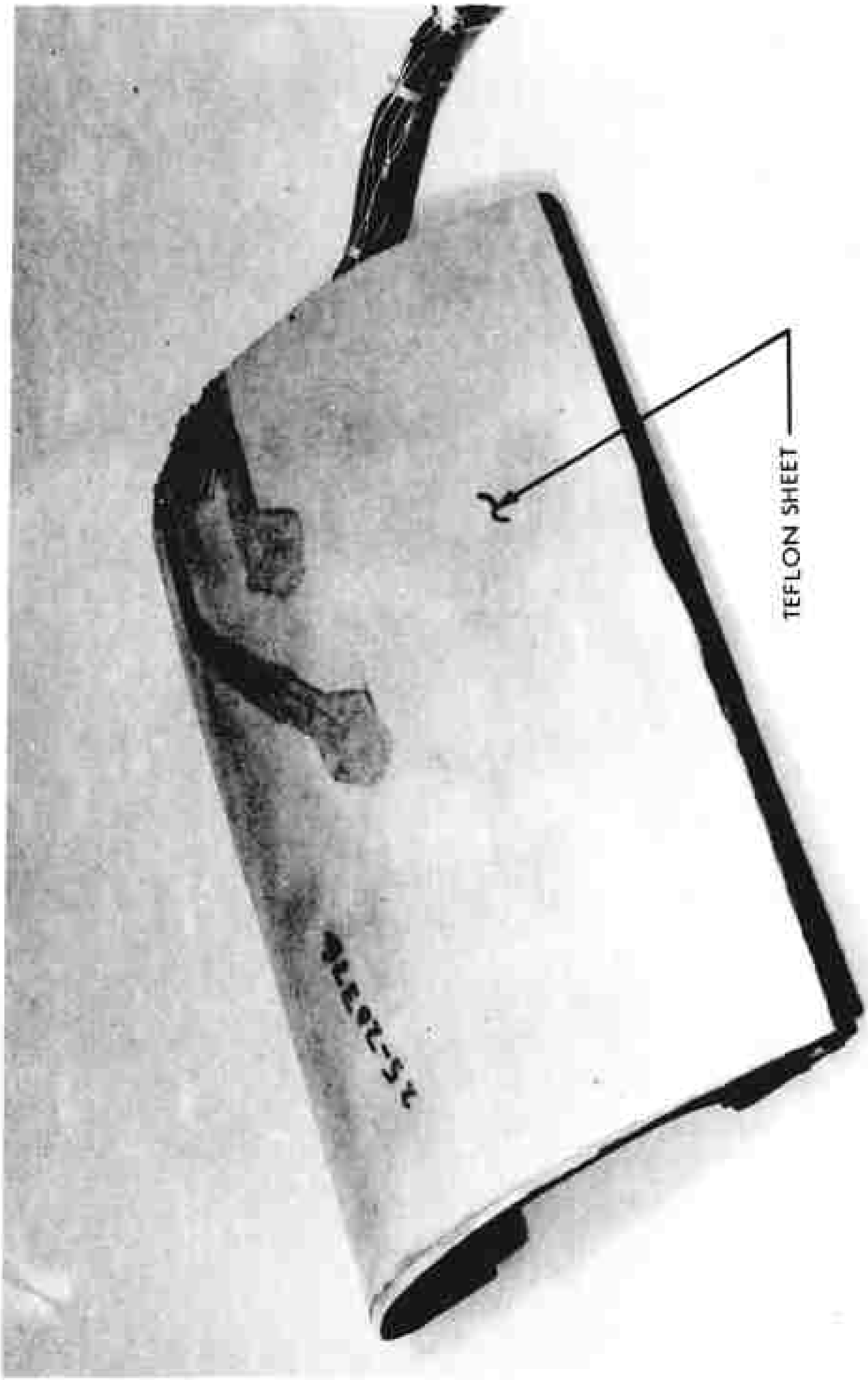
25-20341-1 BEFORE LOAD TEST



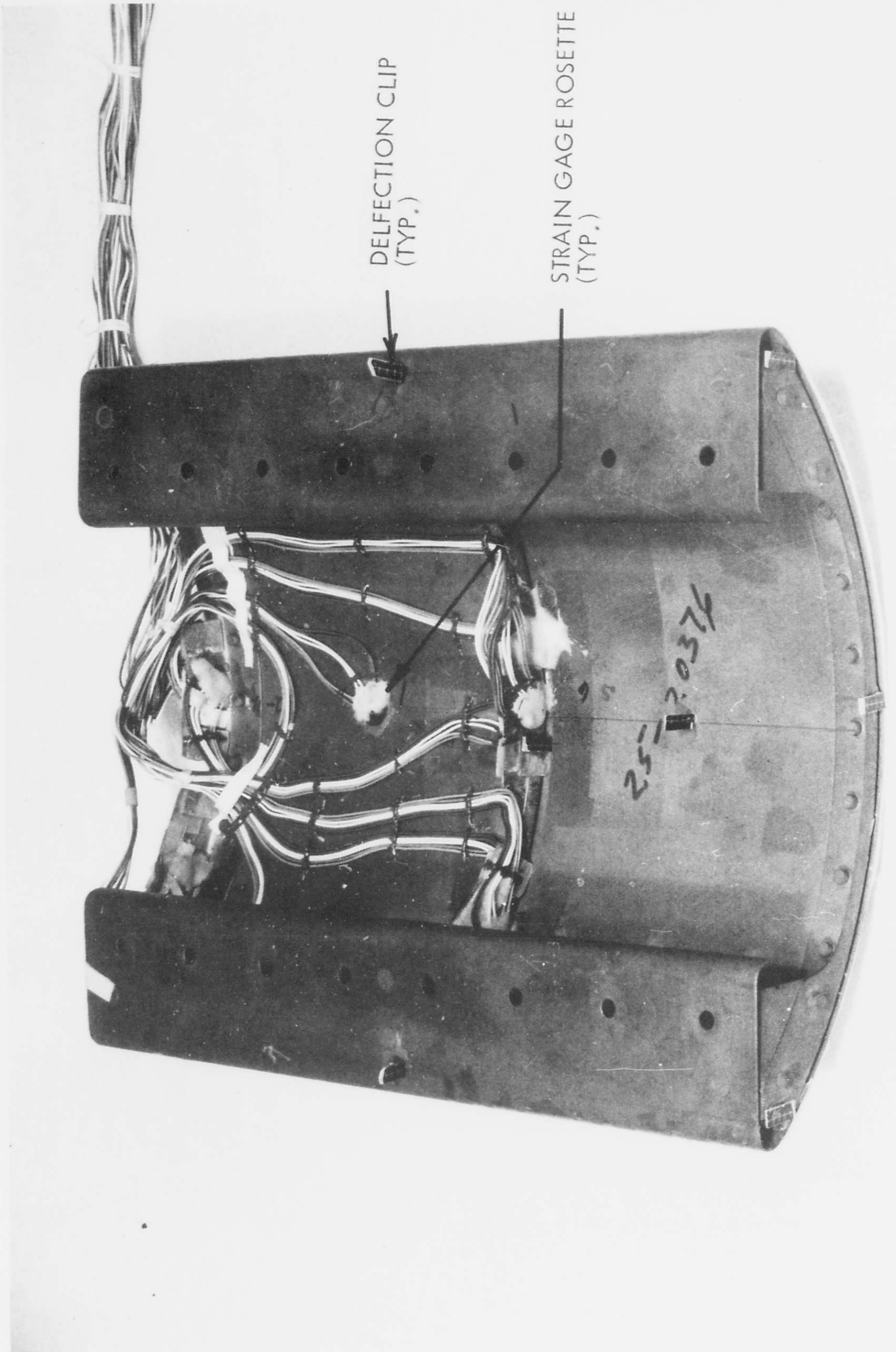
25-20341-1 BEFORE LOAD TEST

DS-I LEADING EDGE #25-20376 BEFORE TESTING - TOP VIEW 1-7-62

2A95728



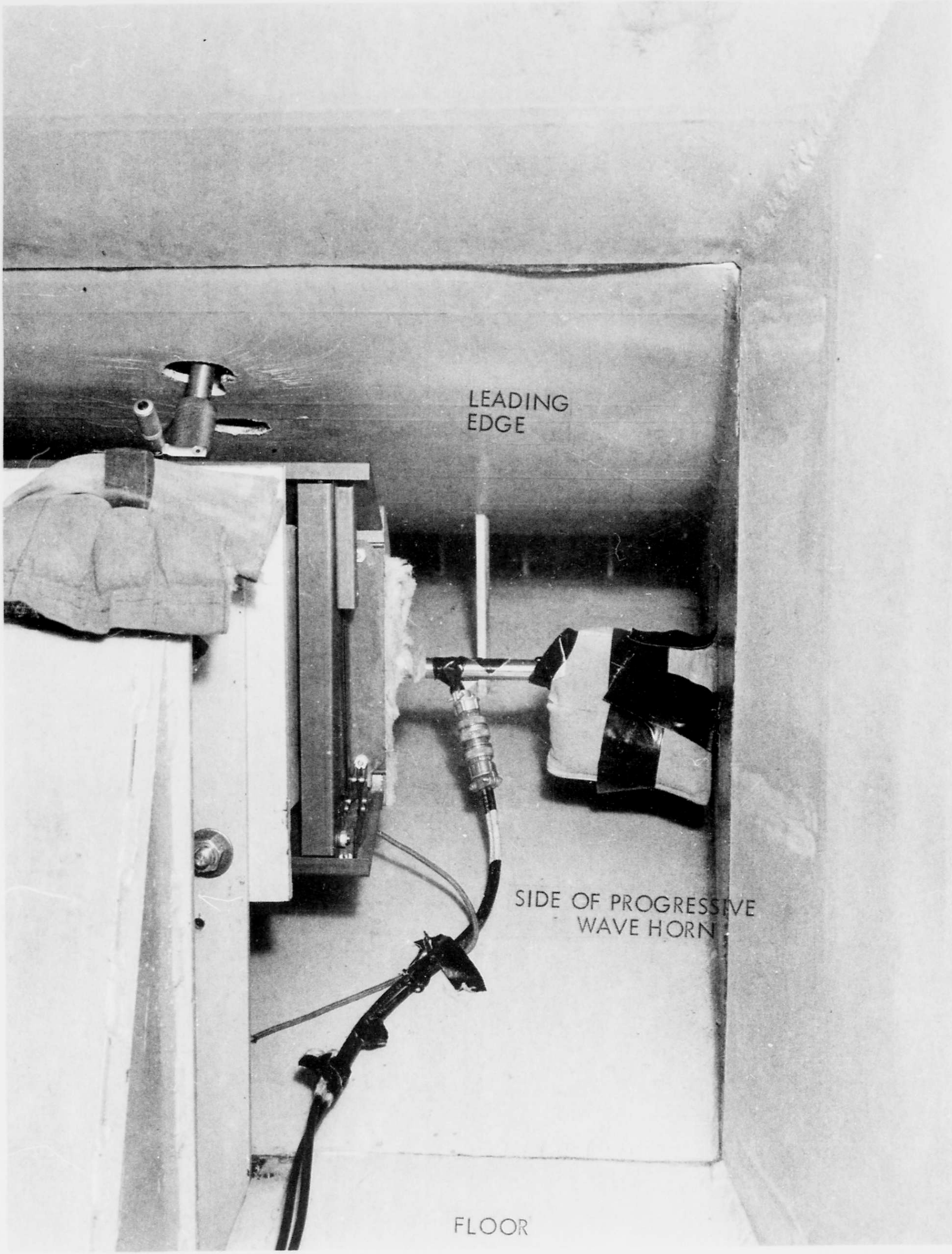
25-20376-1 BEFORE TEST



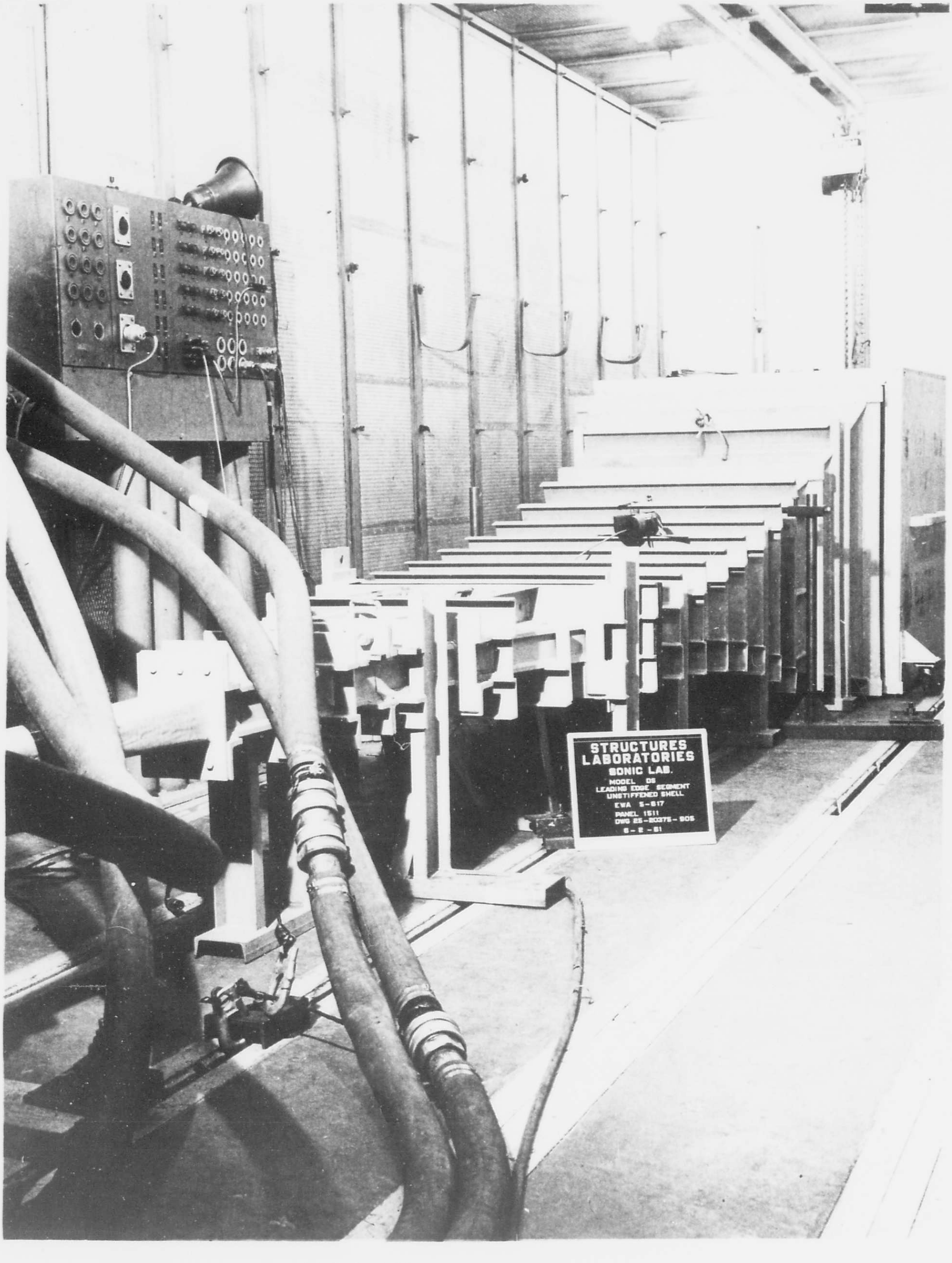
D3-I LEADING EDGE #25-20376 BEFORE
TESTING - BACK VIEW 1-7-62

2A95727

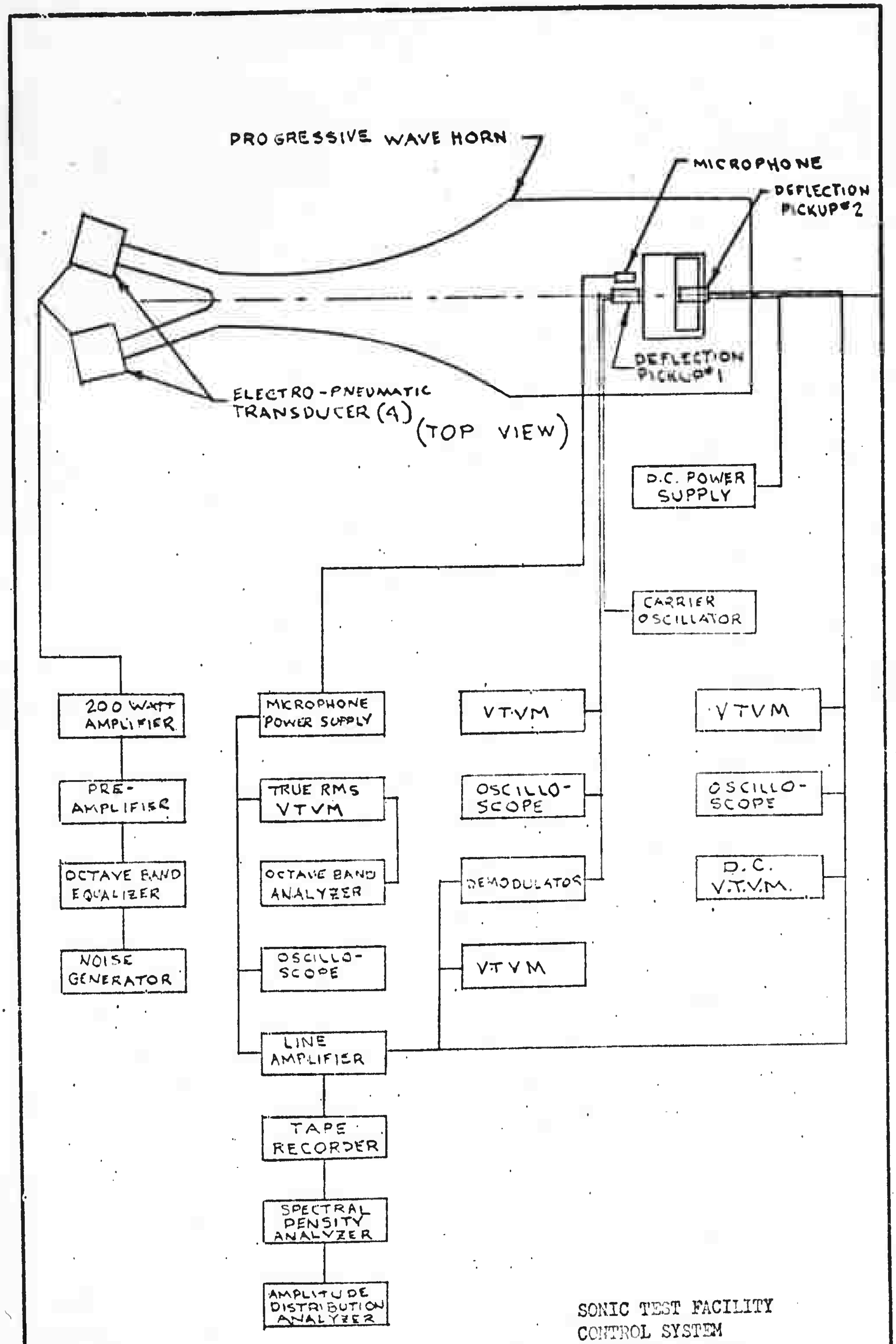
25-20376-I BEFORE TEST



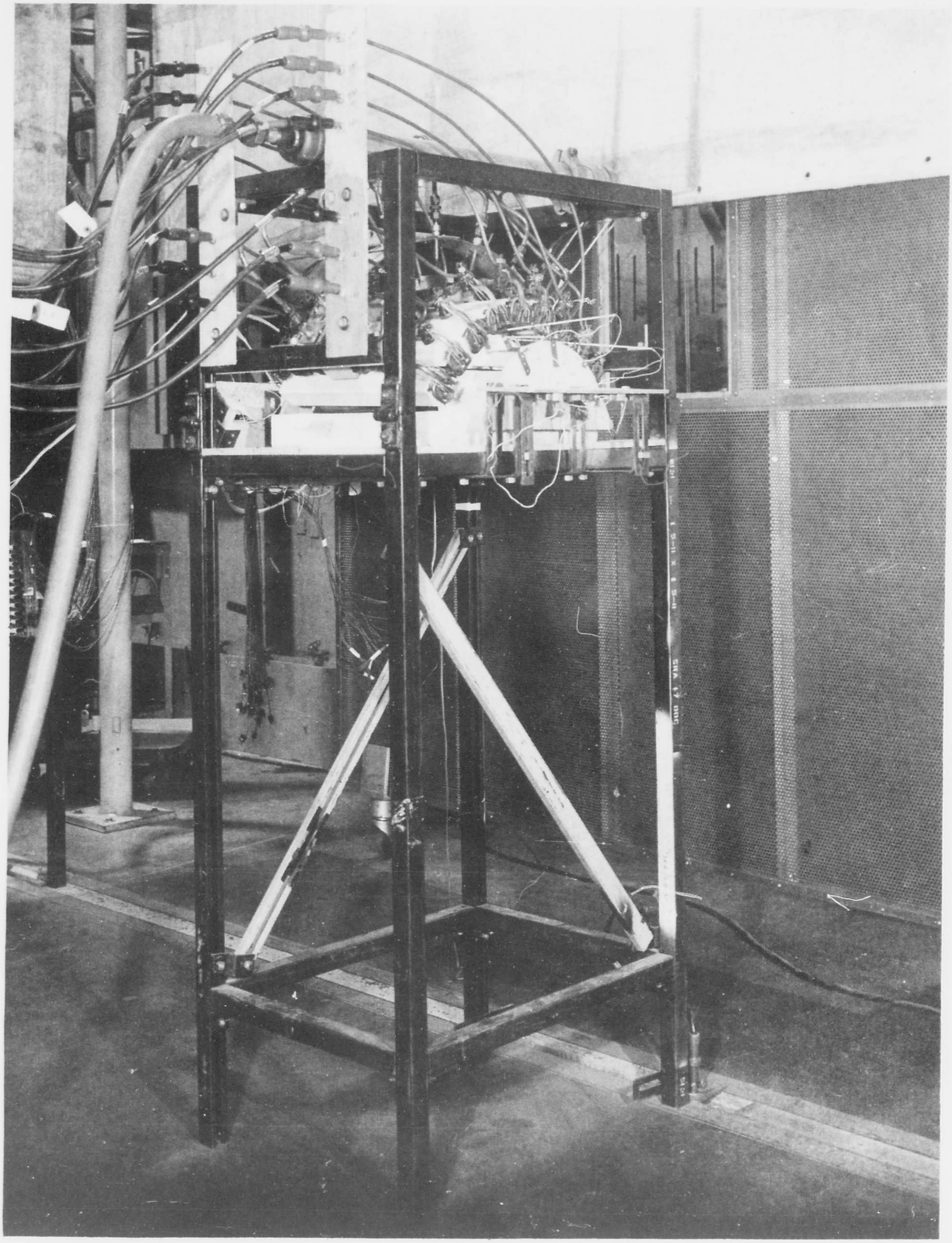
LEADING EDGE POSITIONED IN PROGRESSIVE WAVE HORN FOR SONIC TEST



PROGRESSIVE WAVE HORN



SONIC TEST FACILITY
CONTROL SYSTEM
SCHEMATIC DIAGRAM



THERMAL GRADIENT TEST FIXTURE

U3-4071-1000 (was BAC 1546-L-R3)

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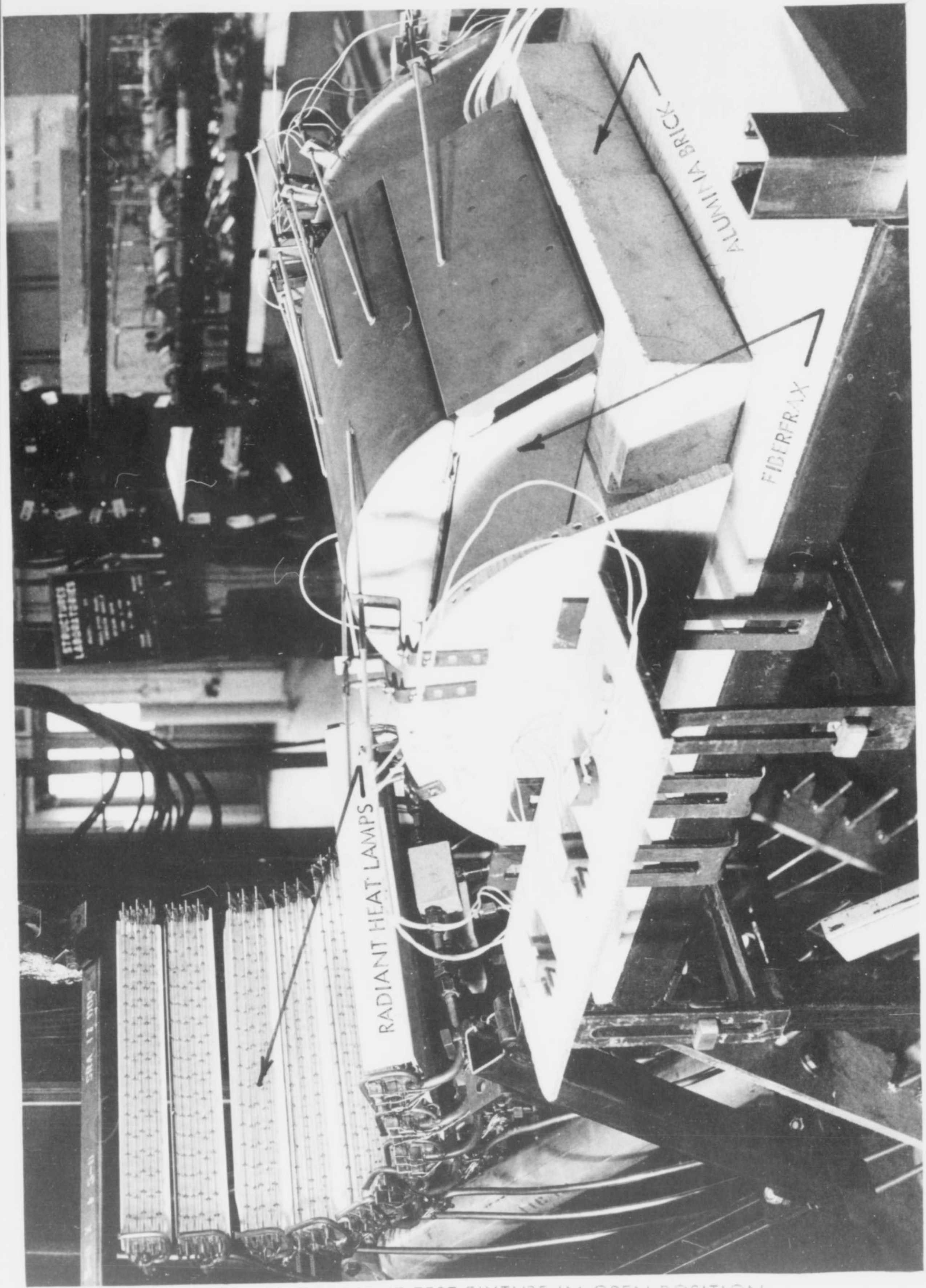
Volume I

BOEING

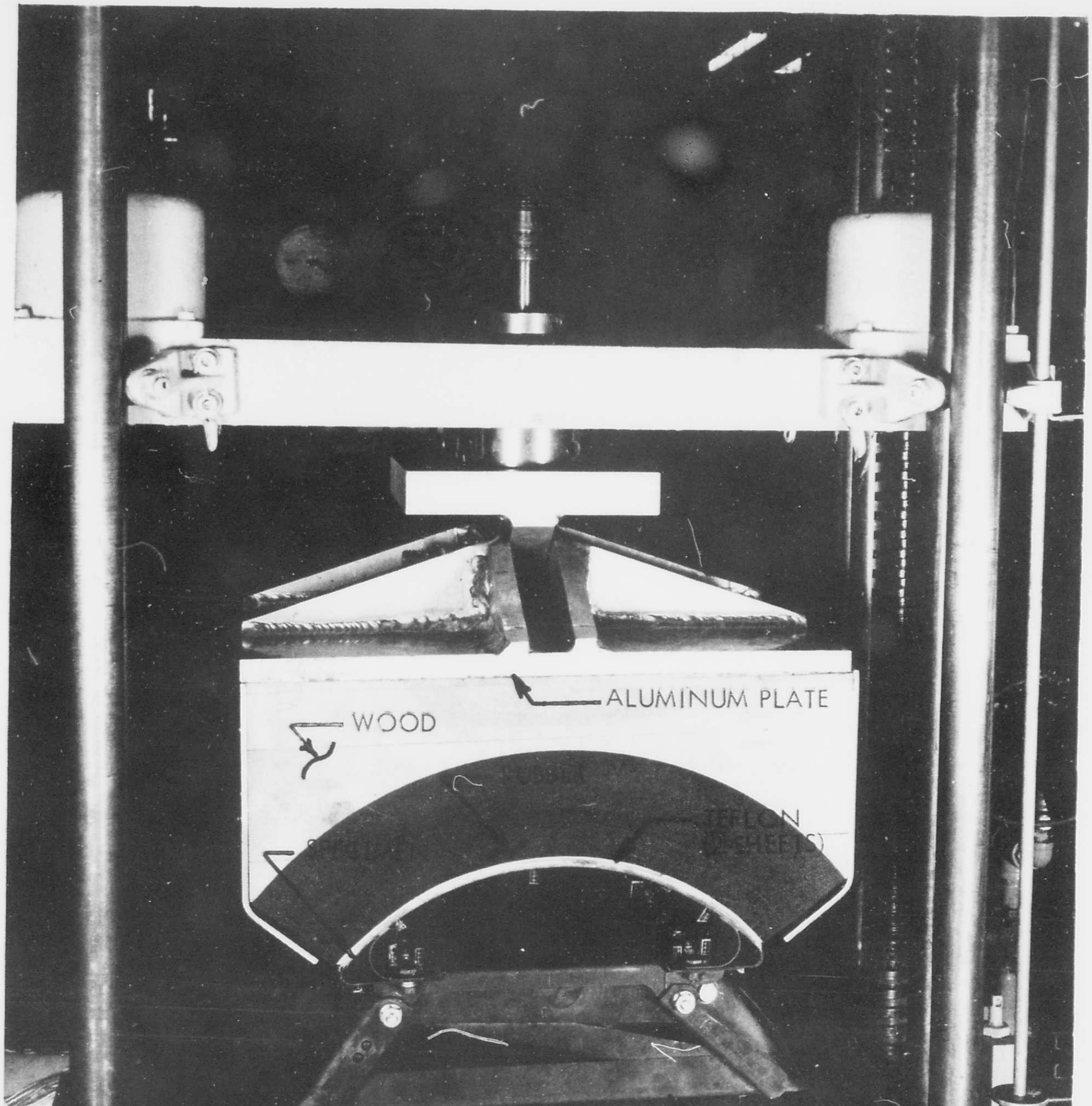
Fig. 3-35.

NO. D2-00085

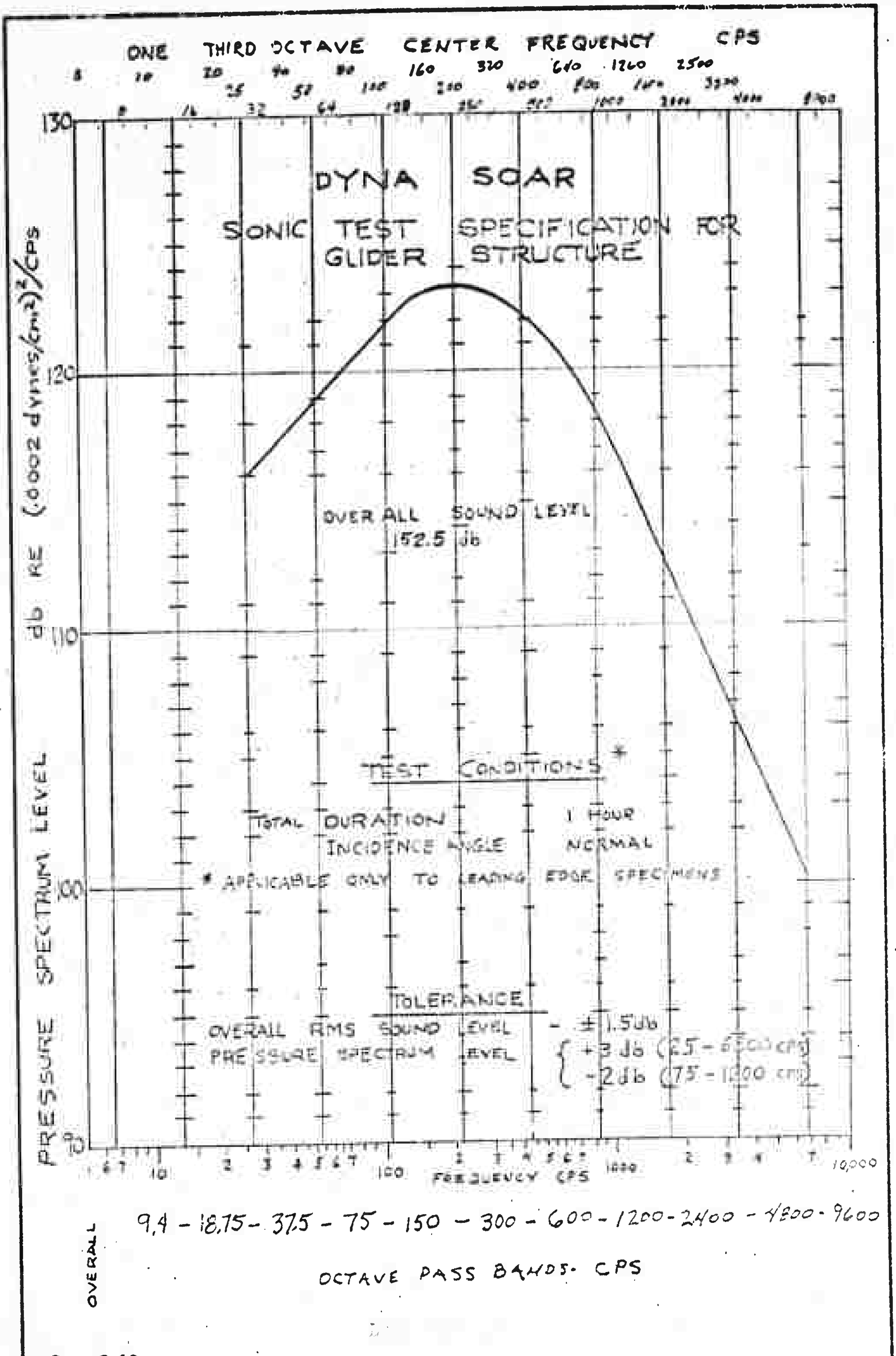


THERMAL GRADIENT TEST FIXTURE IN OPEN POSITION

BEFORE HEAT TEST



LOAD TEST FIXTURE



LCS 11-9-60

U3-4071-1000

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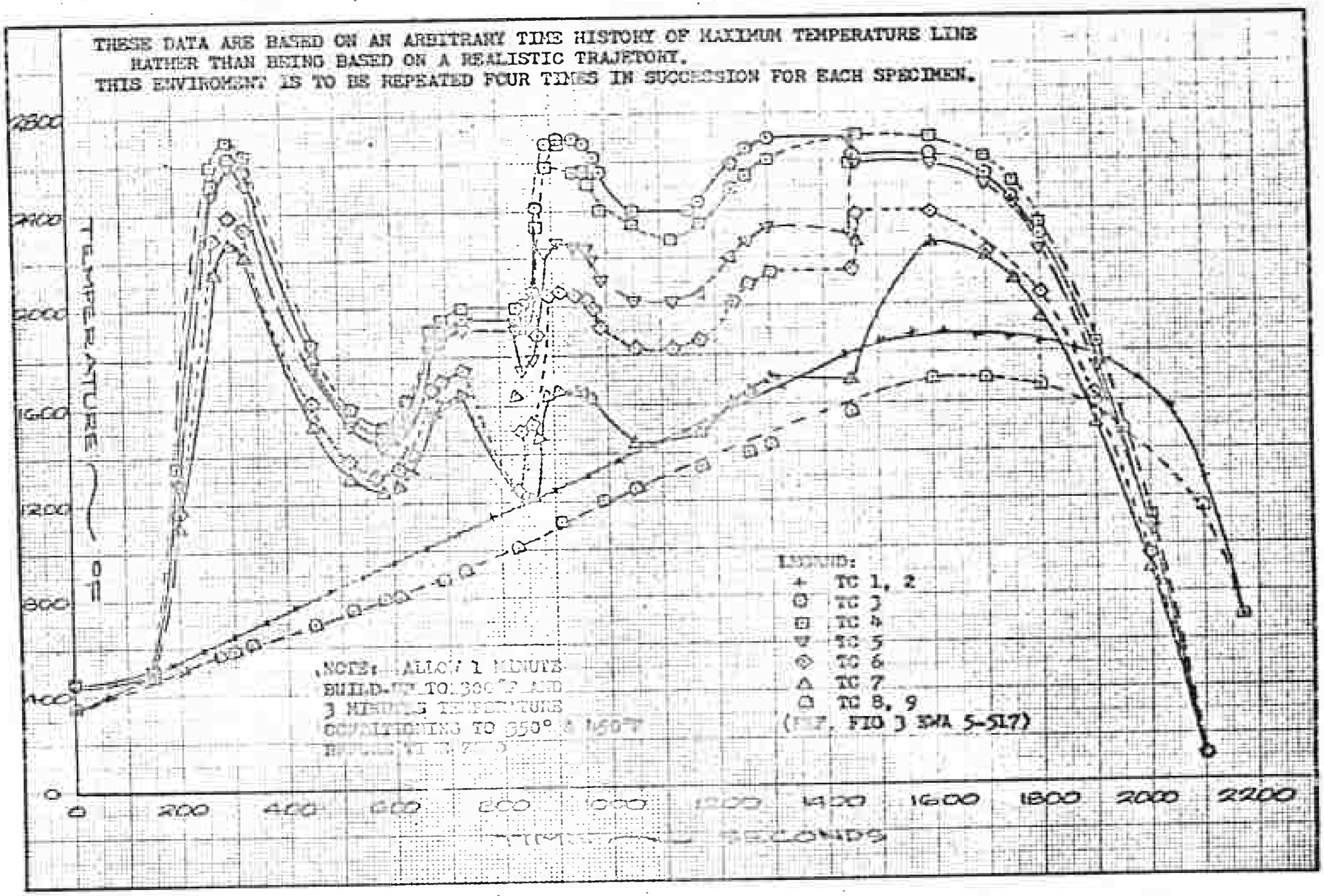

U3-4071-1000

THERMAL GRADIENT TEST PROGRAM
(MANEUVER CYCLE)

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BOEING

NO. D2-80085

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3-37 Fig. 3-39

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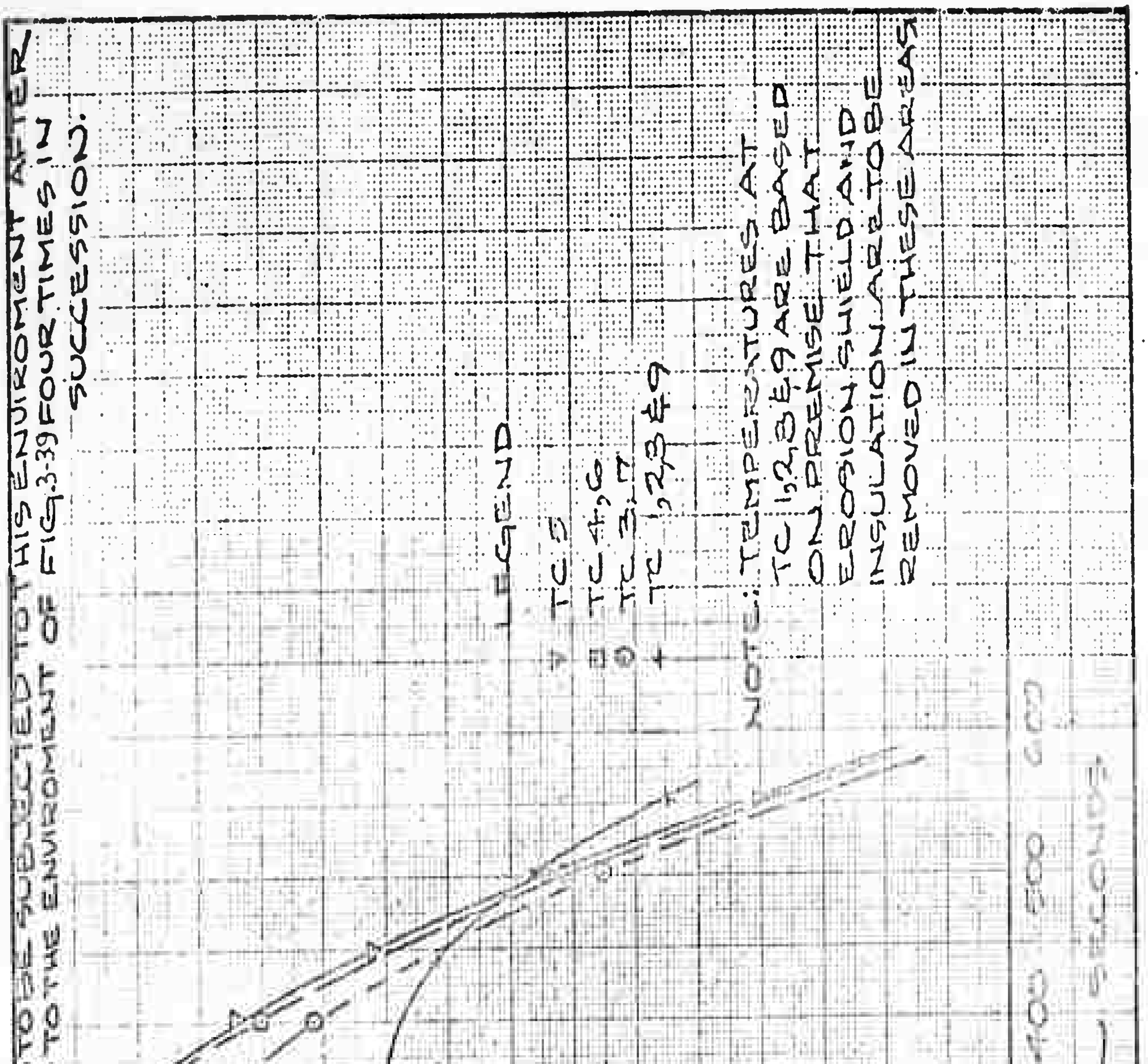
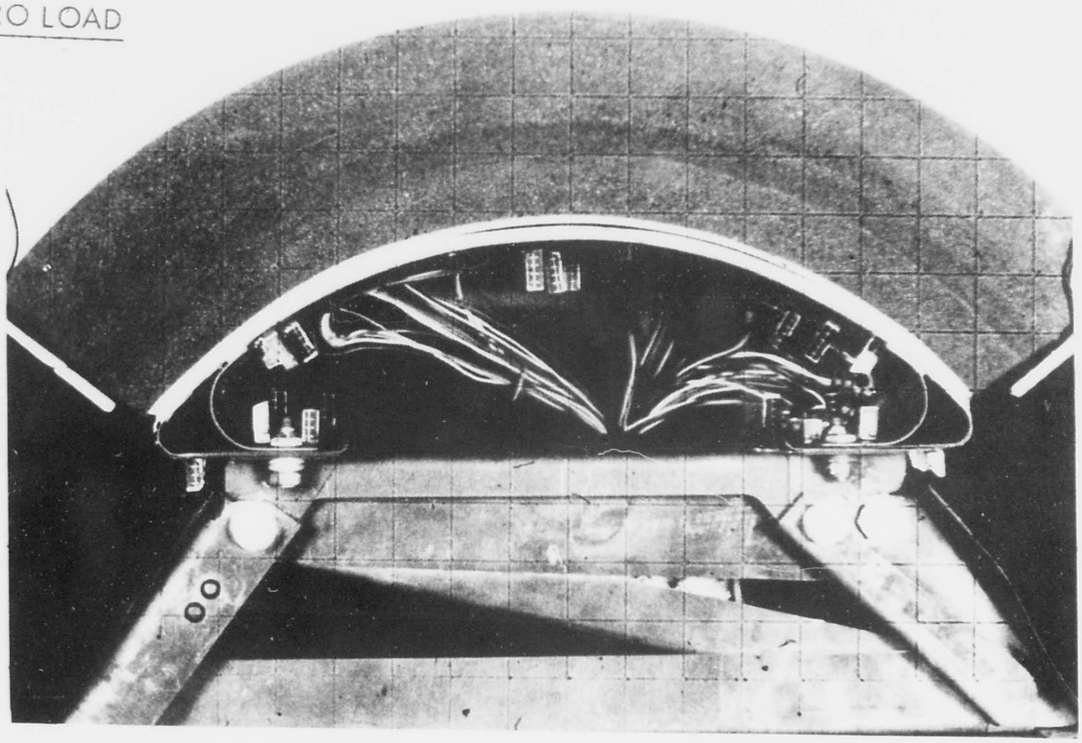
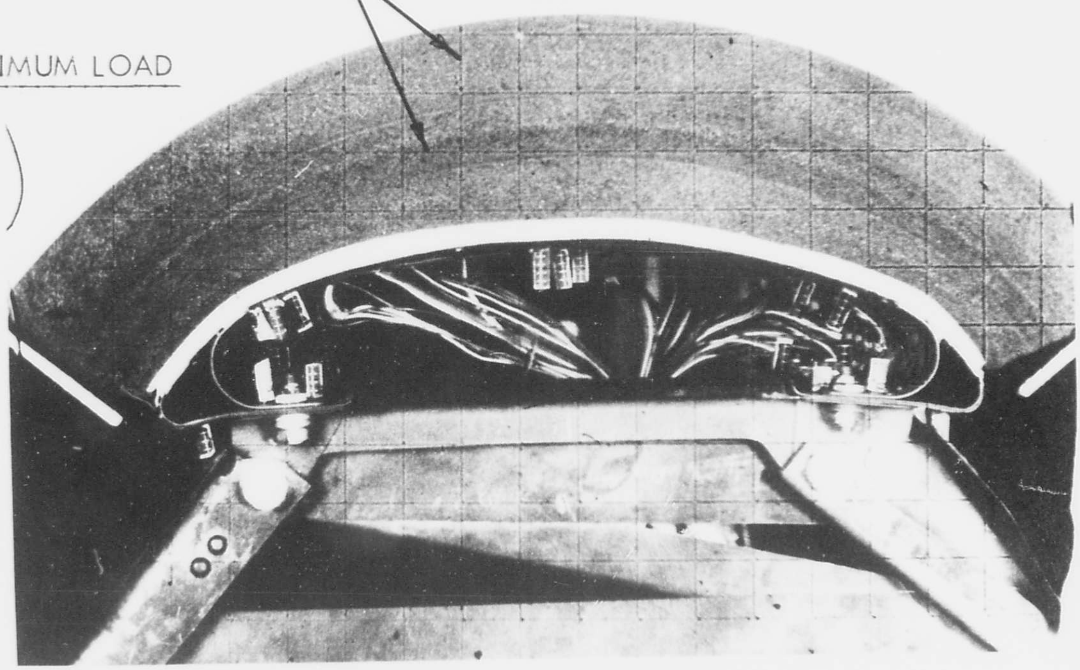

NOTE: EACH SPECIMEN IS TO BE SUBJECTED TO THIS ENVIRONMENT AFTER
IT HAS BEEN EXPOSED TO THE ENVIRONMENT OF FIG. 3-39 FOUR TIMES IN
SUCCESSION.
LEGEND
TC 5
TC 4,6
TC 3,7
TC 1,2,8 & 9
NOTE: TEMPERATURES AT
TC 1,2,8 & 9 ARE BASED
ON PREMISE THAT
EROSION SHIELD AND
INSULATION ARE TO BE
REMOVED IN THESE AREAS
TEMPERATURE ~ °F
0
400
800
1200
1600
2000
2400
2800
0
100
200
300
400
500
600
TIME ~ SECONDS

ZERO LOAD



GRID LINES OVER LENS OF CAMERA FOR PHOTOGRAPHIC DEFLECTION MEASUREMENT

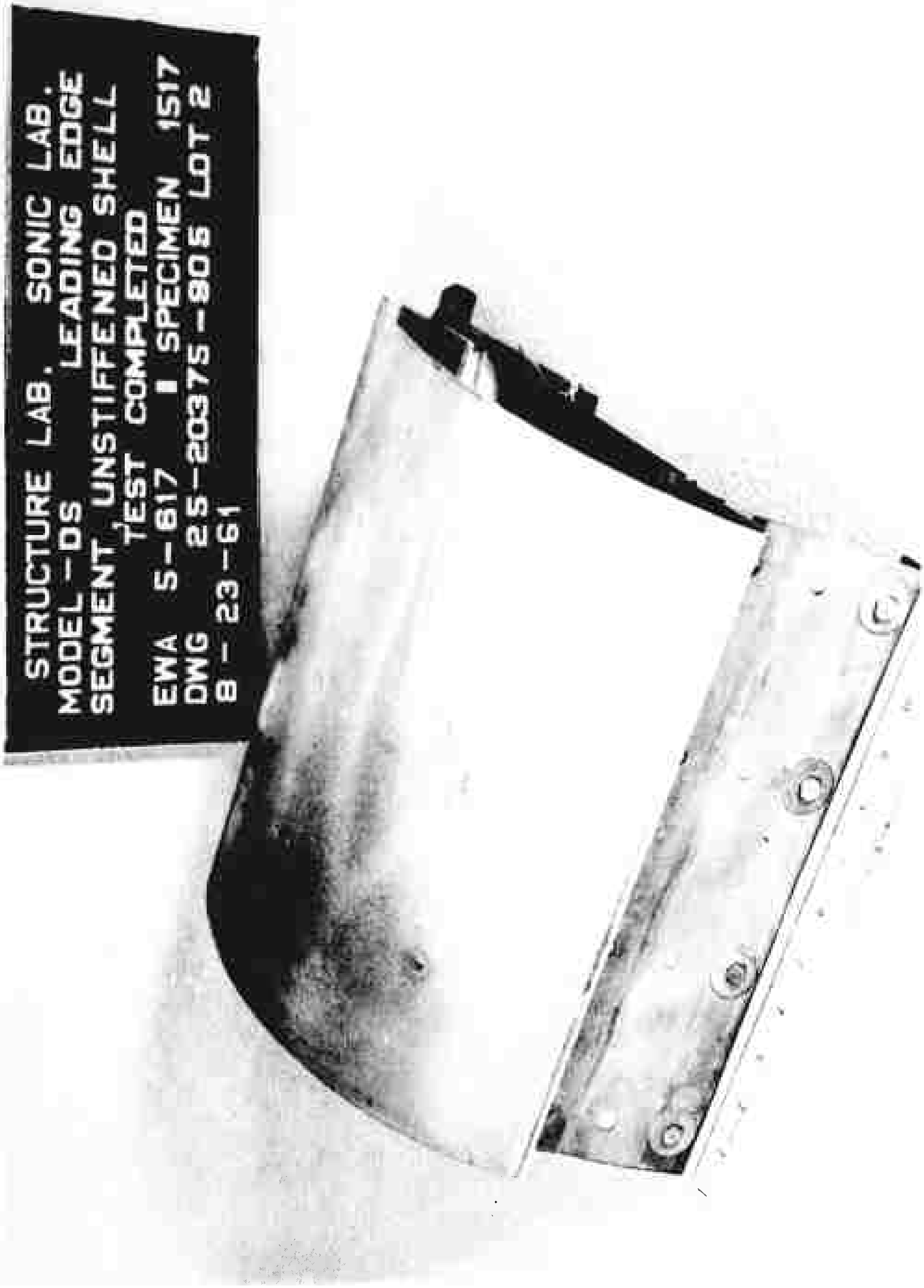
MAXIMUM LOAD



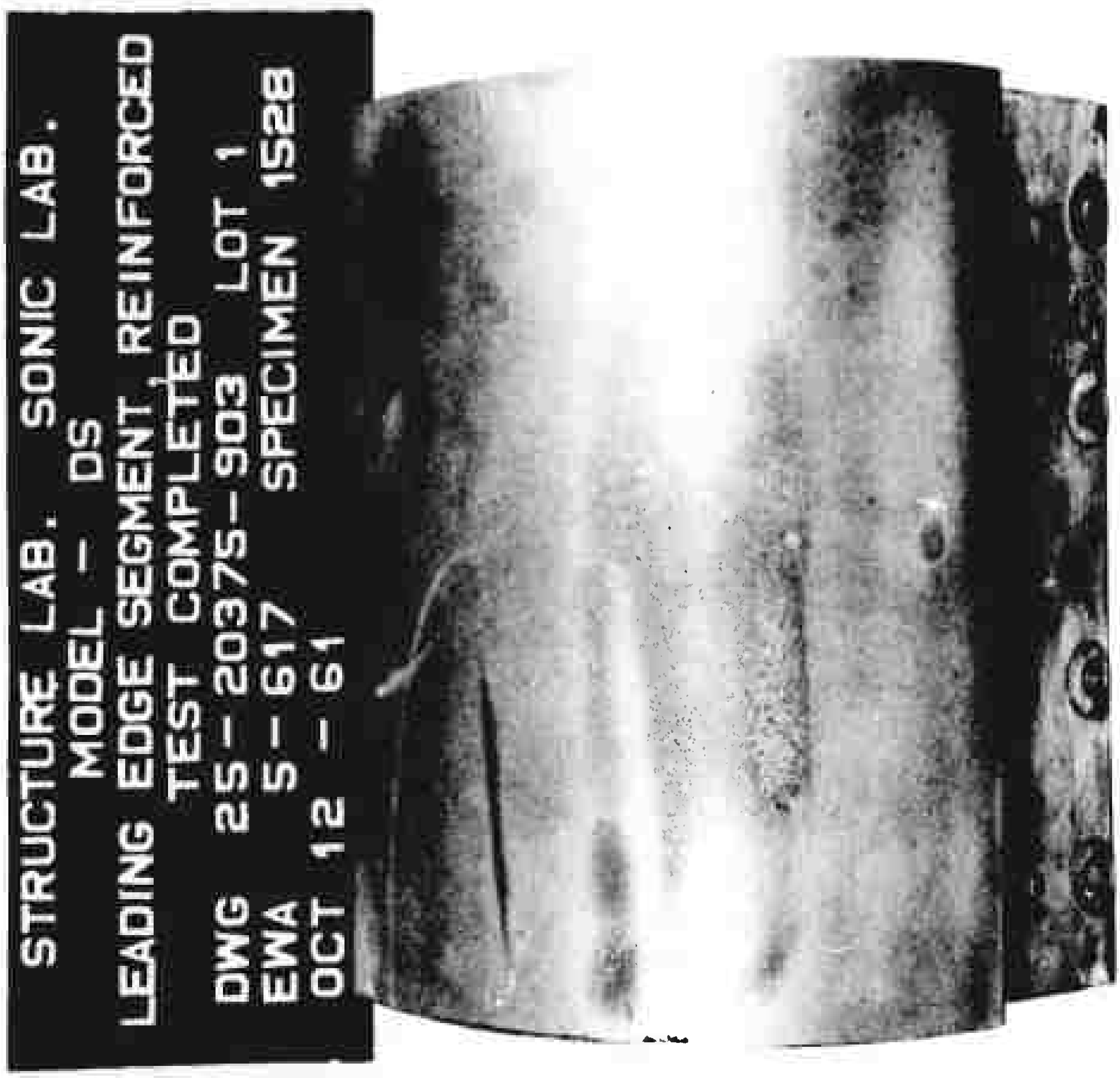
SPECIMEN 25-20367-1 DISPLAYING TYPICAL LOAD AND DEFLECTION MEASUREMENT TECHNIQUE

25-20372-1 AFTER SONIC TEST

DS-I- LEADING EDGE - SL 1517 (25-20375-905 2A87159
LOT 2) TOP VIEW 8-24-61

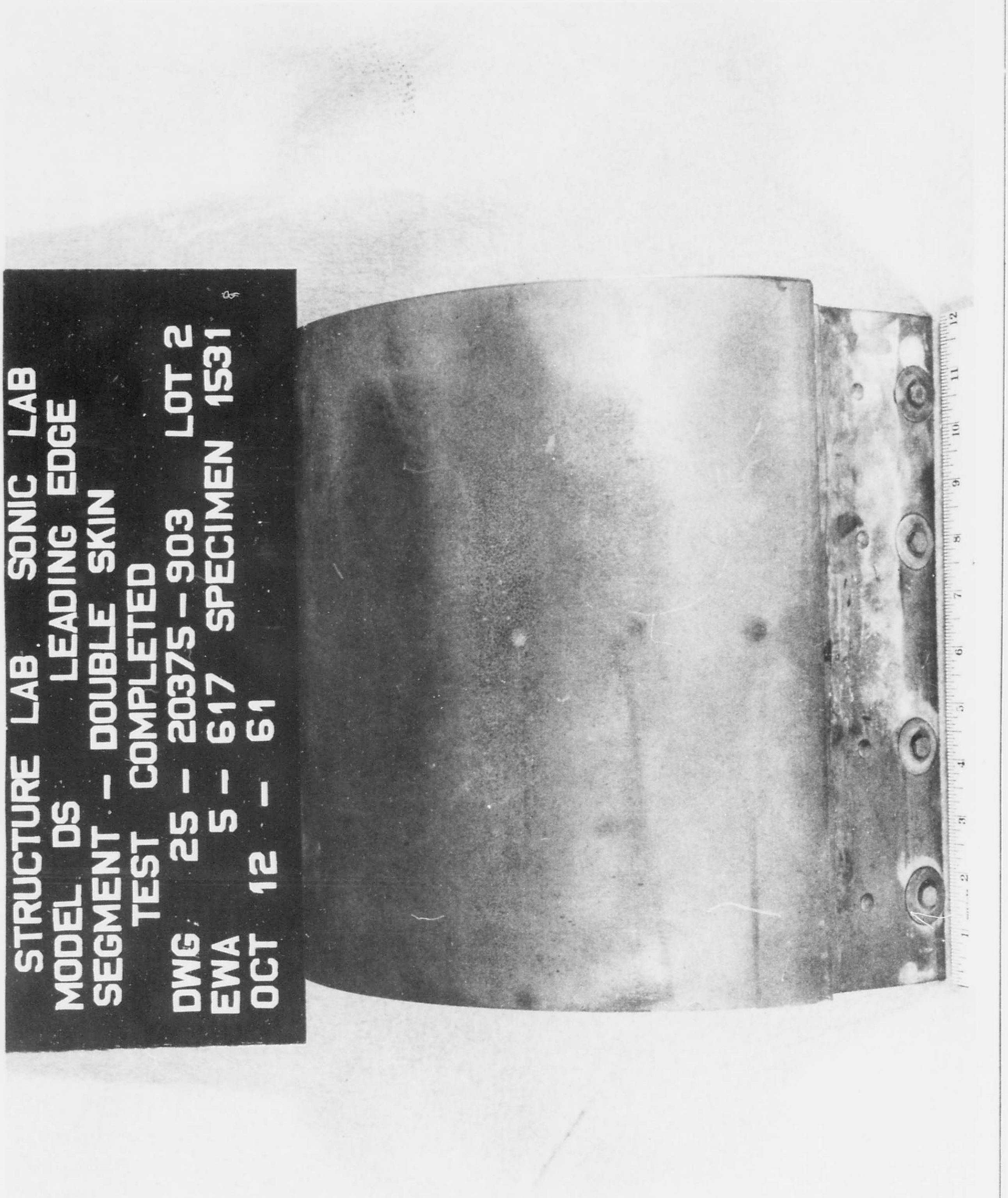


25-20372-2 AFTER SONIC TEST

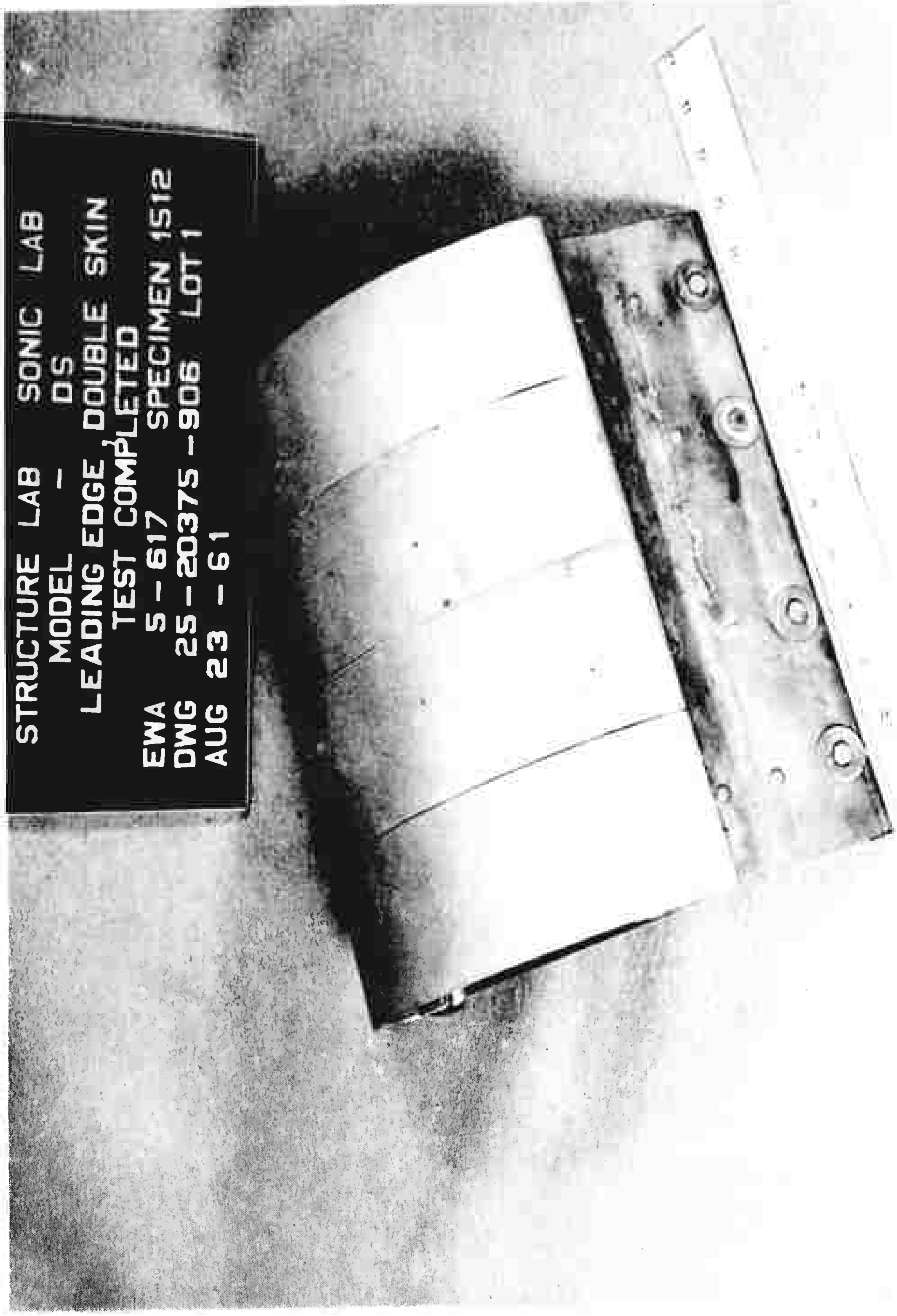


DS-1 REINFORCED LEADING EDGE - TEST COMPLETED 2A90627
EWA 5-617 #1528 25-20375-903 LOT 1 FRONT
VIEW 10-13-61

25-20367-1 AFTER SONIC TEST



25-20367-2 AFTER SONIC TEST

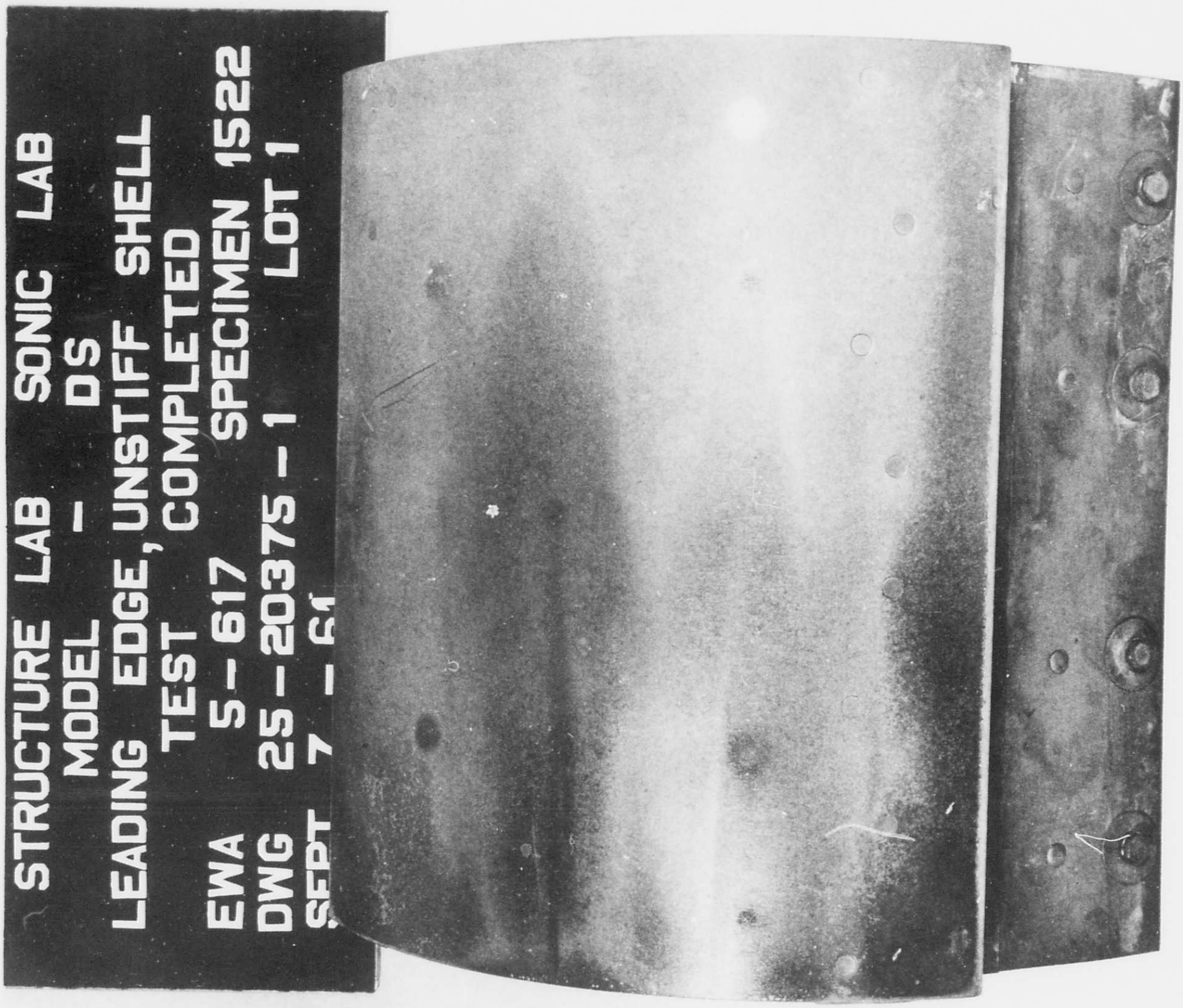


DS-I-LEADING EDGE - SL 1512 (25-20375-906 8-24-61 2A87157
LOT 1) TOP VIEW

25-20378-1 AFTER SONIC TEST

DS-I LEADING EDGE DOUBLE SKIN AFTER SONIC ENVIRON CLOSE UP SPEC. #1518 7-21-61 2A83562

25-20378-2 AFTER SONIC TEST



25-20341-1 AFTER SONIC TEST

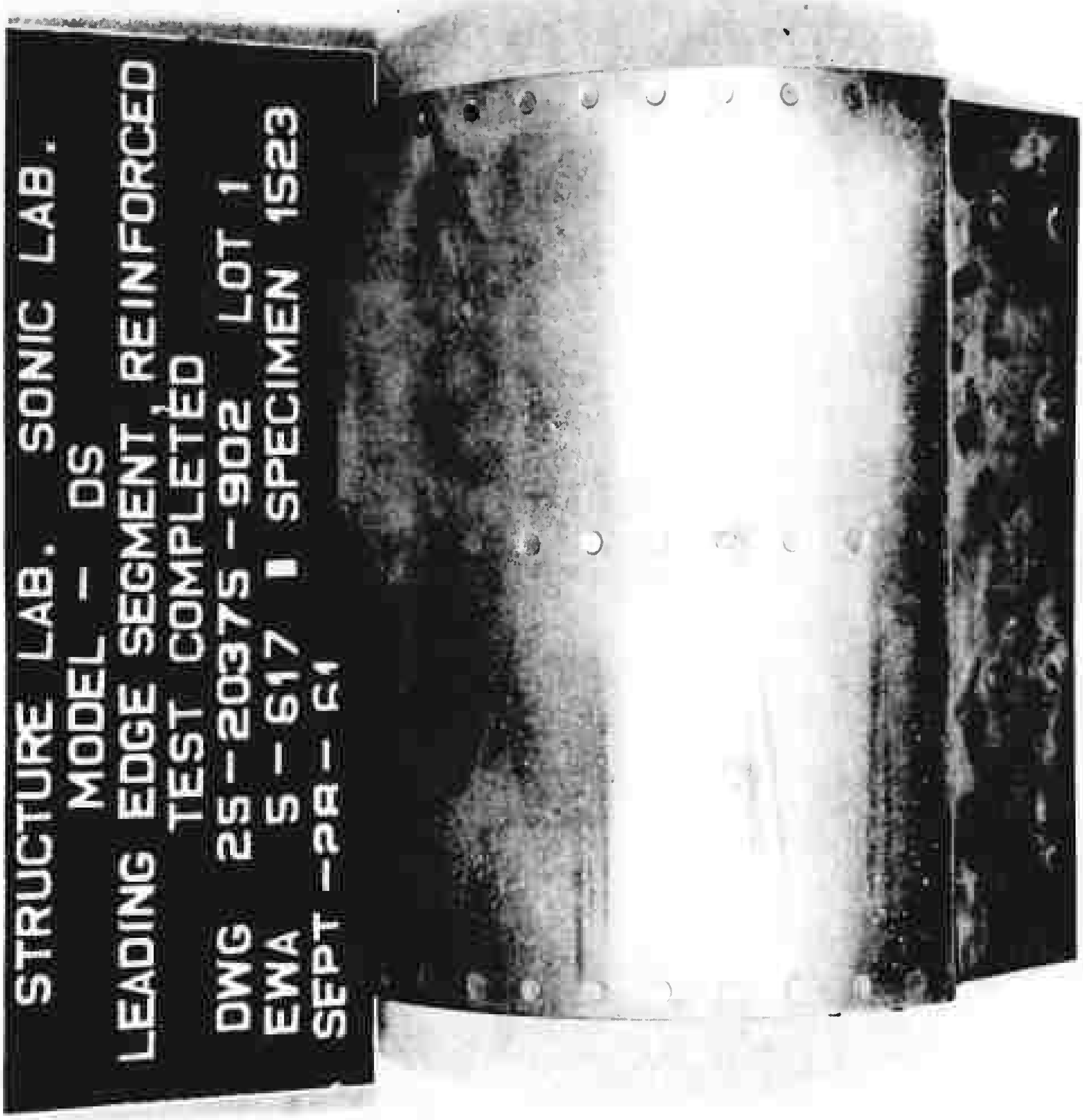
Fig. 3-48

DS-I LEADING EDGE SEGMENT EWA 5-617 - 1532 TEST 2A92277
COMPLETED - FRONT VIEW 10-30-61

25-20341-2 AFTER SONIC TEST

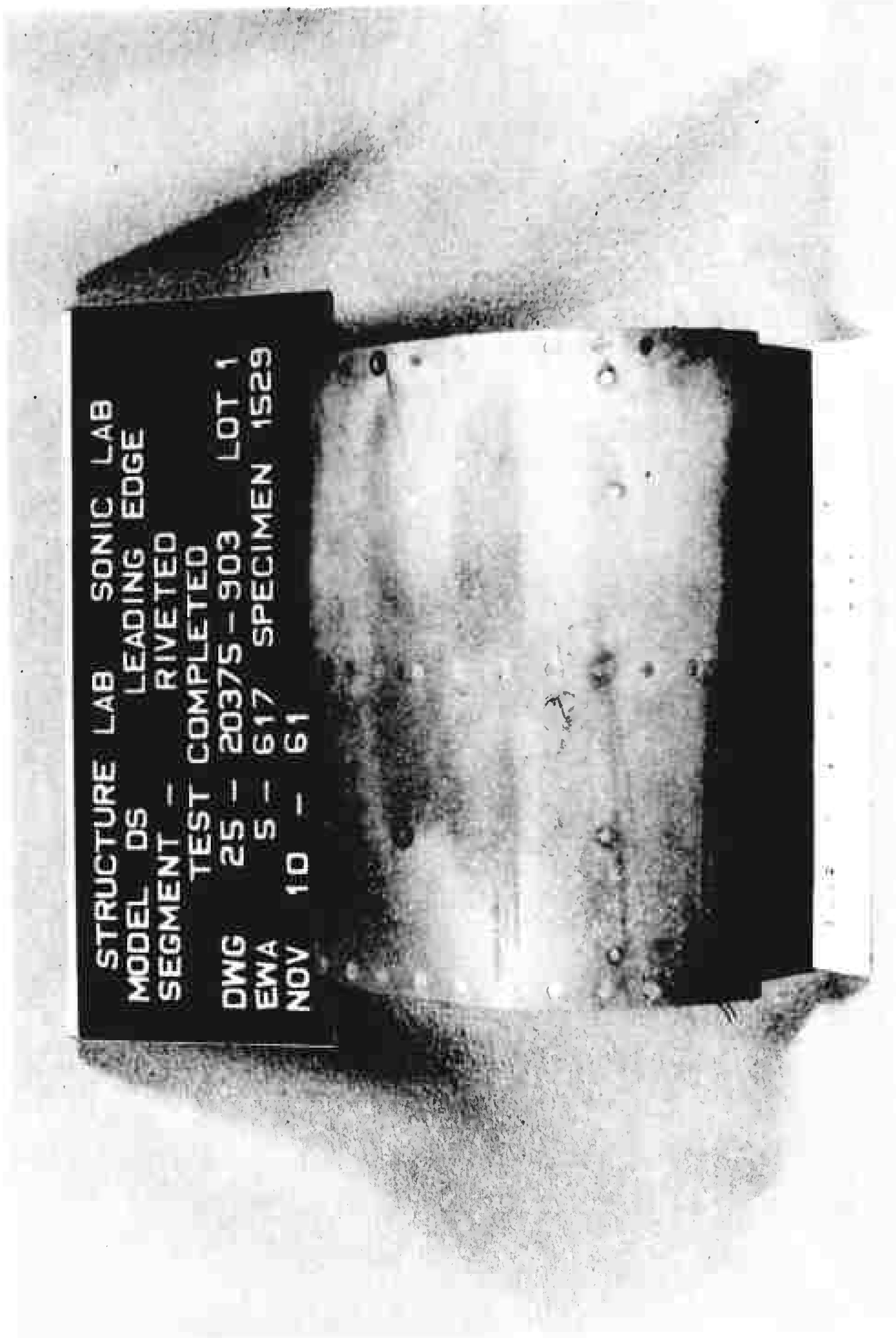
Fig. 3-49

DS-I LEADING EDGE, RENE TEST COMPLETED (EWA 5-617) #1523 BACK VIEW 25-20375-902 LOT 1 9-28-61 2A89134



25-20376-I AFTER SONIC TEST

DS-I - LEADING EDGE (RIVETED) EWA 1529 FRONT VIEW 11-11-61 2A9267



25-20376-2 AFTER SONIC TEST

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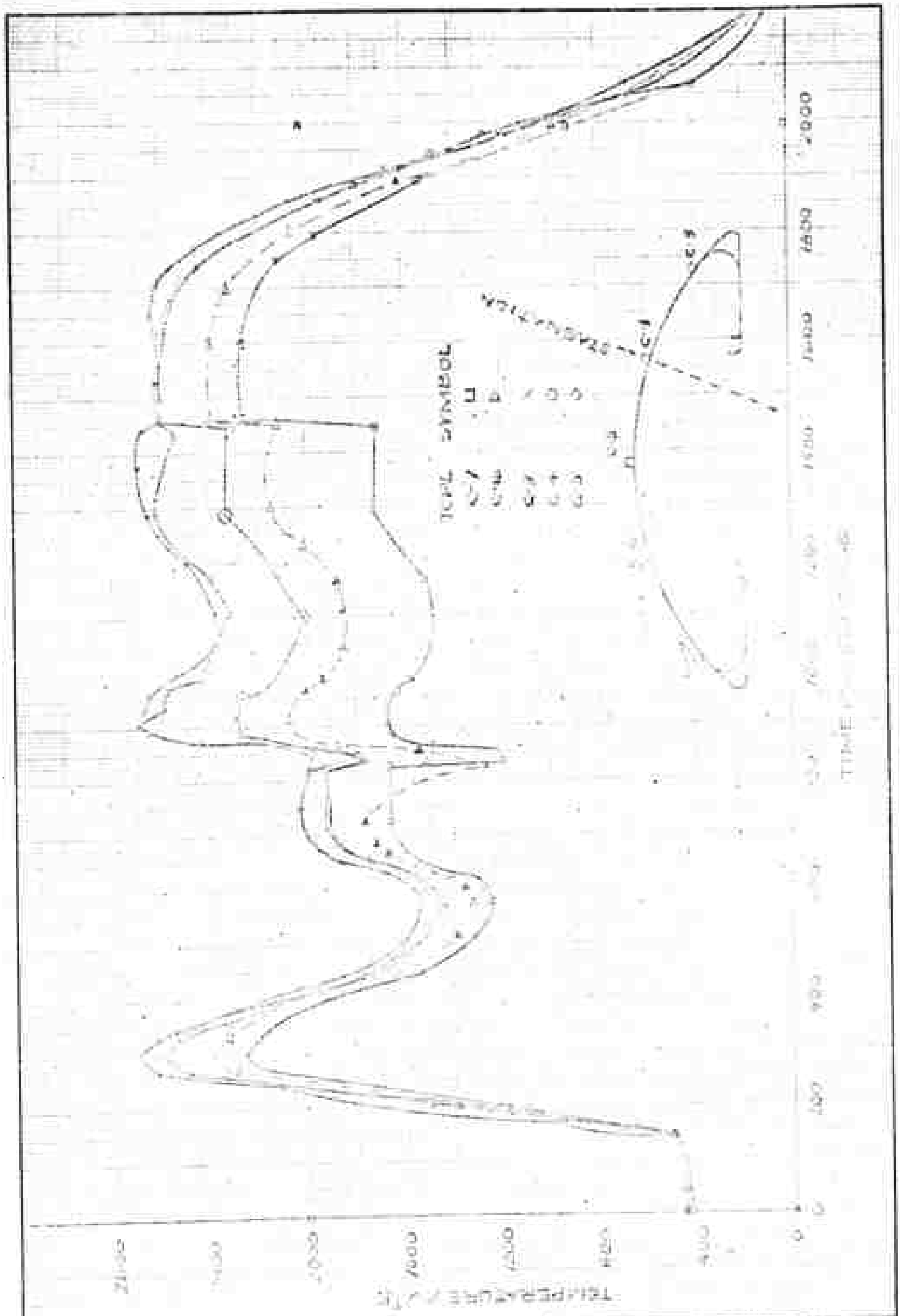

CALC			REVISED	DATE
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APR				
APR				

X TYPICAL TRAJECTORY
THERMAL GRADIENT CYCLE
FORWARD LEADING EDGE

BOEING AIRPLANE COMPANY
SEATTLE 24, WASHINGTON

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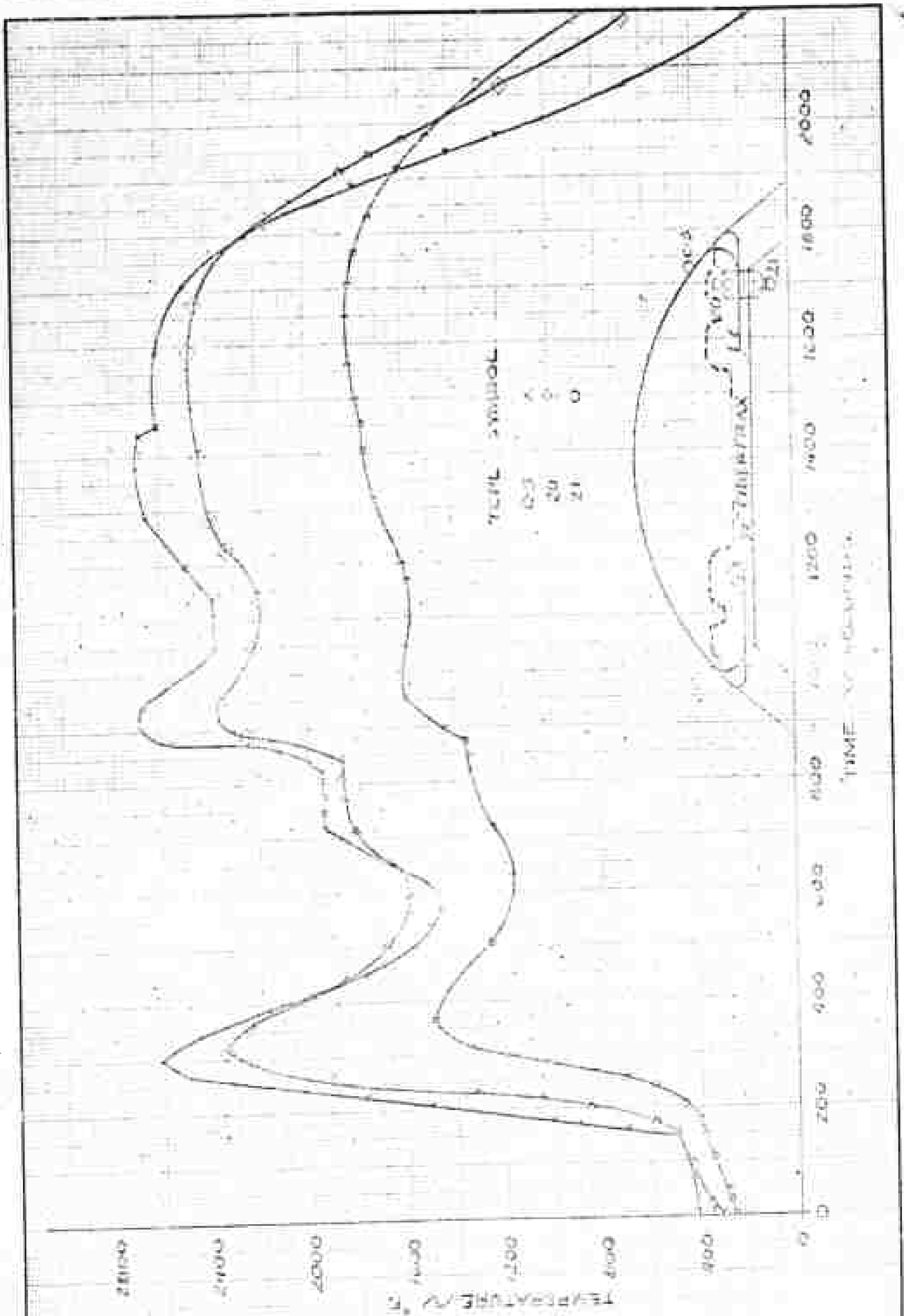

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APR				

A TYPICAL TRAJECTORY
THERMAL GRADIENT CYCLE
FORWARD LEADING EDGE

BOEING AIRPLANE COMPANY
SEATTLE 24, WASHINGTON

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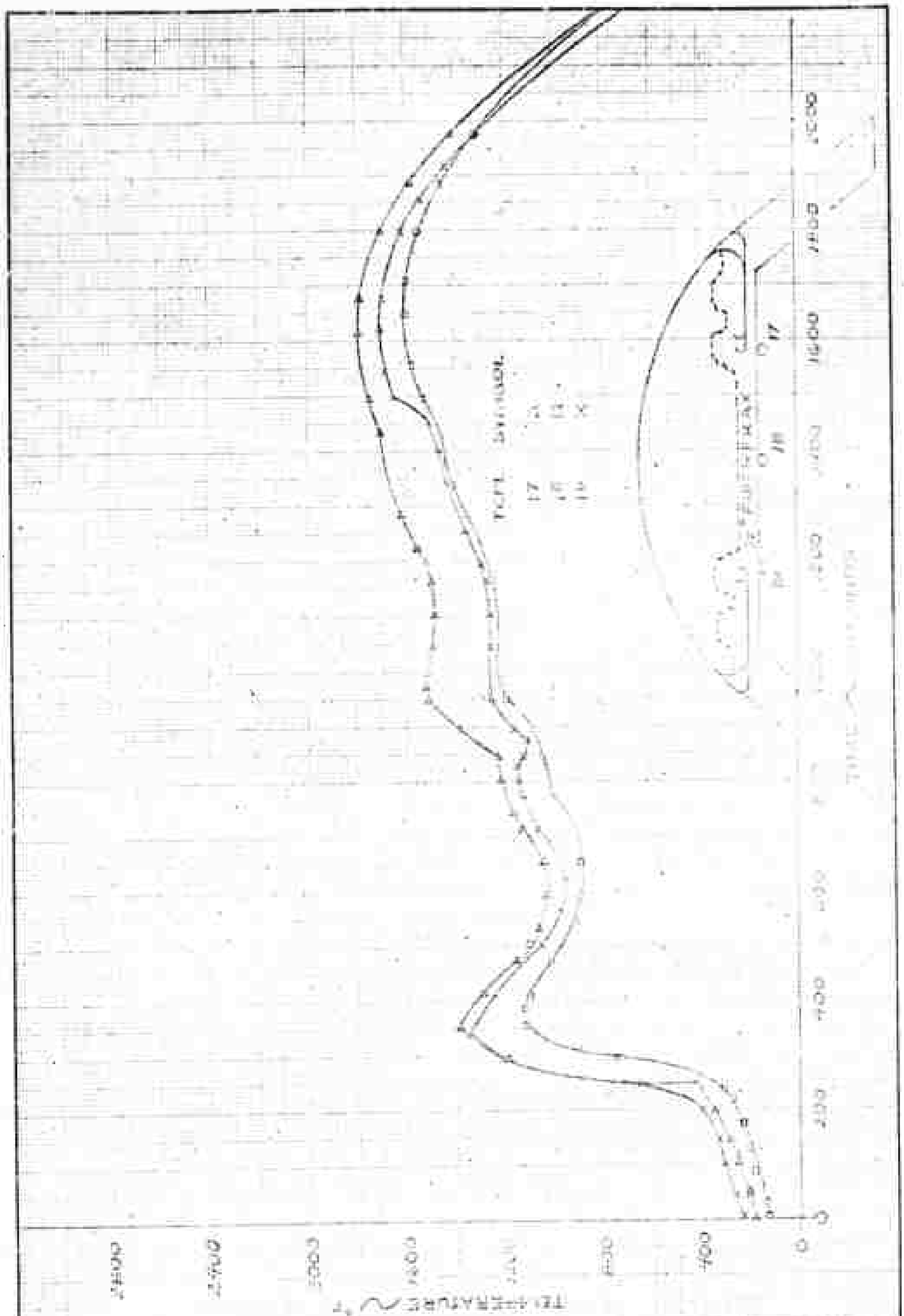
H-E ALBANENE TRACING PAPER



CALC	[illegible signature]	[illegible]	REVISED	DATE	A TYPICAL TRAJECTORY THERMAL GRADIENT CYCLE FORWARD LEADING EDGE
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APR					BOEING AIRPLANE COMPANY SEATTLE 24, WASHINGTON
APR					

Sect. 3

PAGE 3-[illegible]

BAC 461 C-R6

9-3-63

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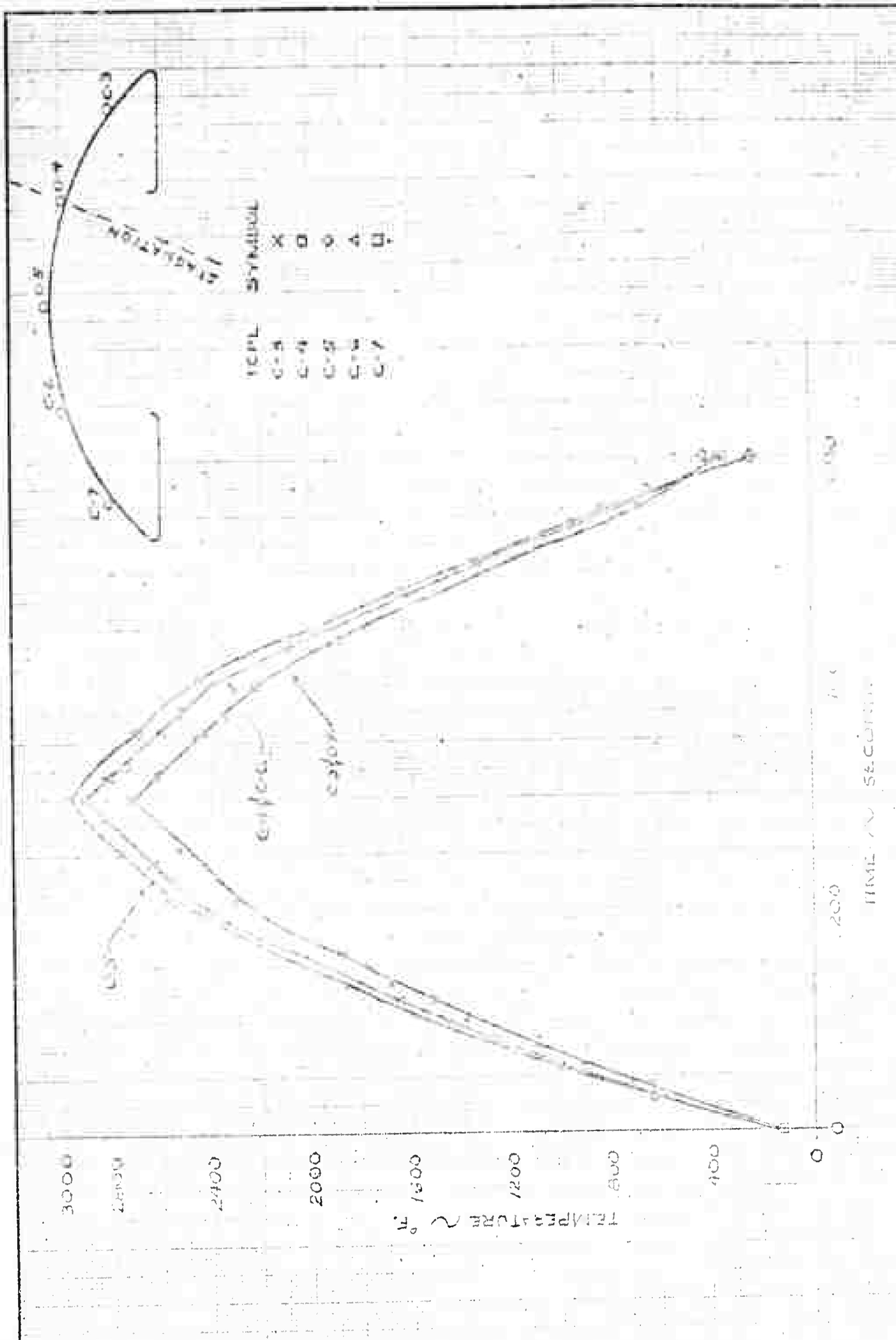

CALC	[illegible]	5-10-63	REVISED	DATE	A TYPICAL MANEUVER THERMAL GRADIENT CYCLE FORWARD LEADING EDGE
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APR					
APR					BOEING AIRPLANE COMPANY SEATTLE 24, WASHINGTON

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Sect. 3

PAGE 3-74
Fig. 3-56

60629

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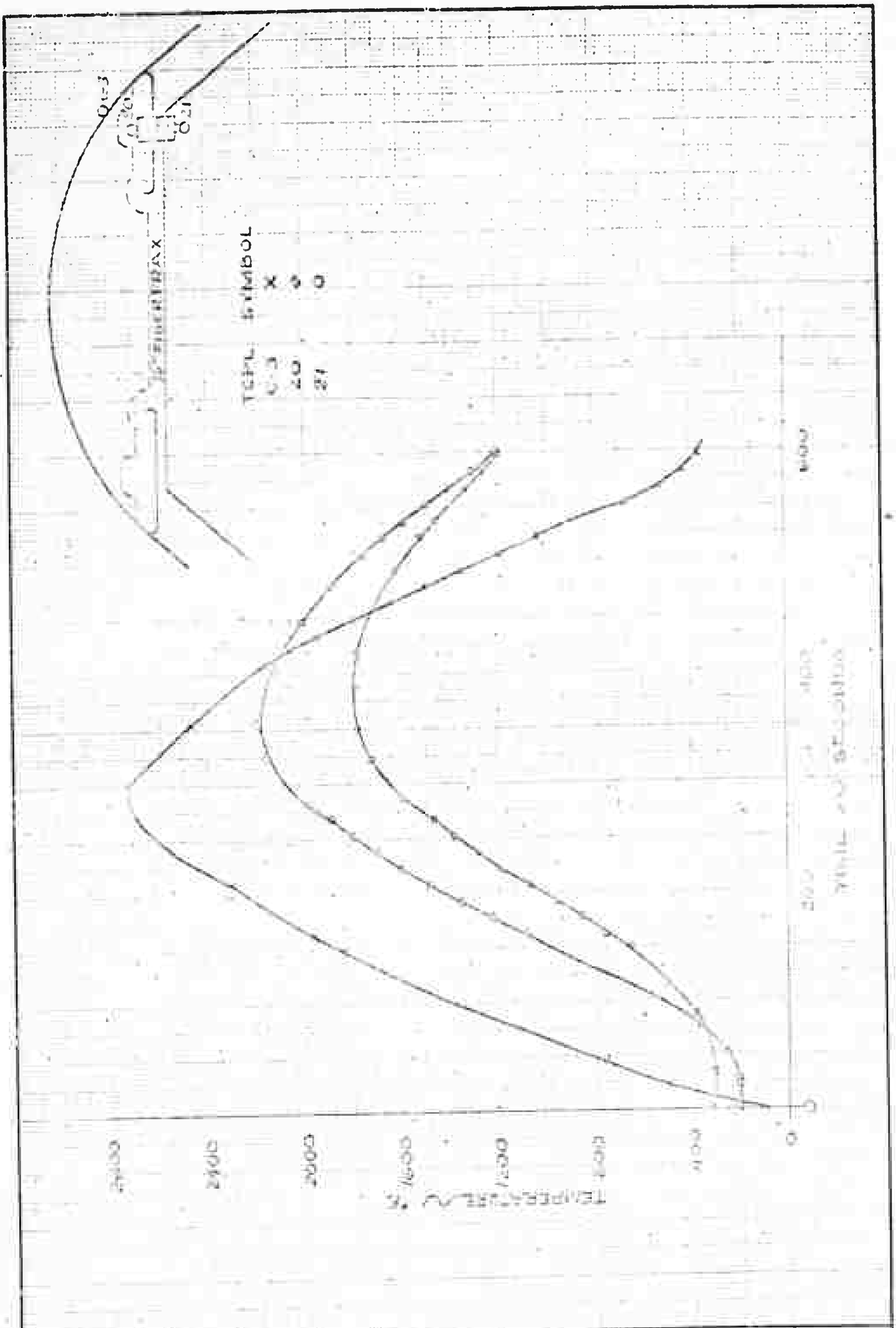
K·E ALBANENE 196L TRACING PAPER



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APR				
APR				

A TYPICAL MANEUVER
THERMAL GRADIENT CYCLE
FORWARD LEADING EDGE

BOEING AIRPLANE COMPANY
SEATTLE 24, WASHINGTON

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PAGE [illegible]
Fig. [illegible]-57

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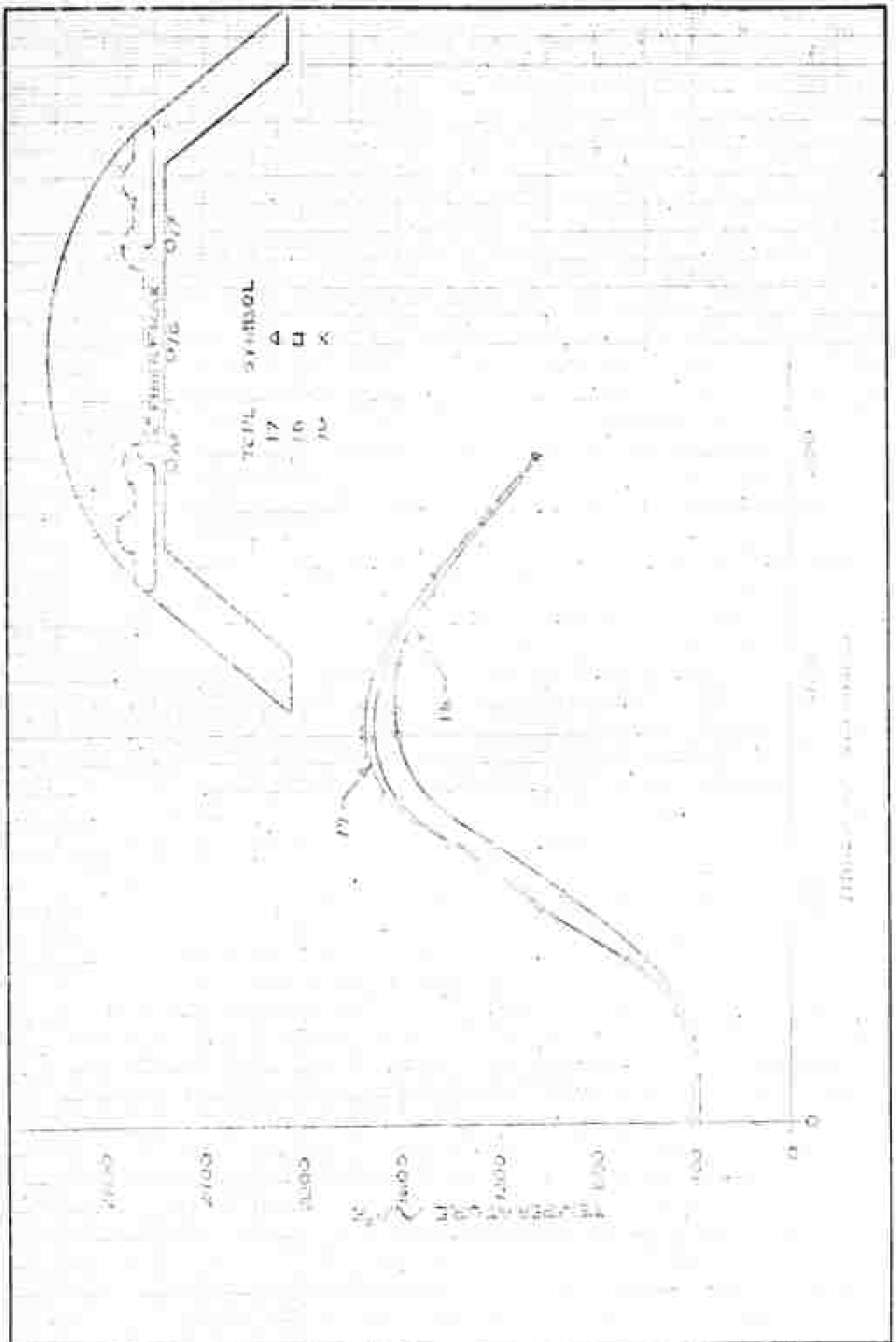

CALC			REVISED	DATE
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APR				
APR				

BOEING AIRPLANE COMPANY
SEATTLE 24, WASHINGTON

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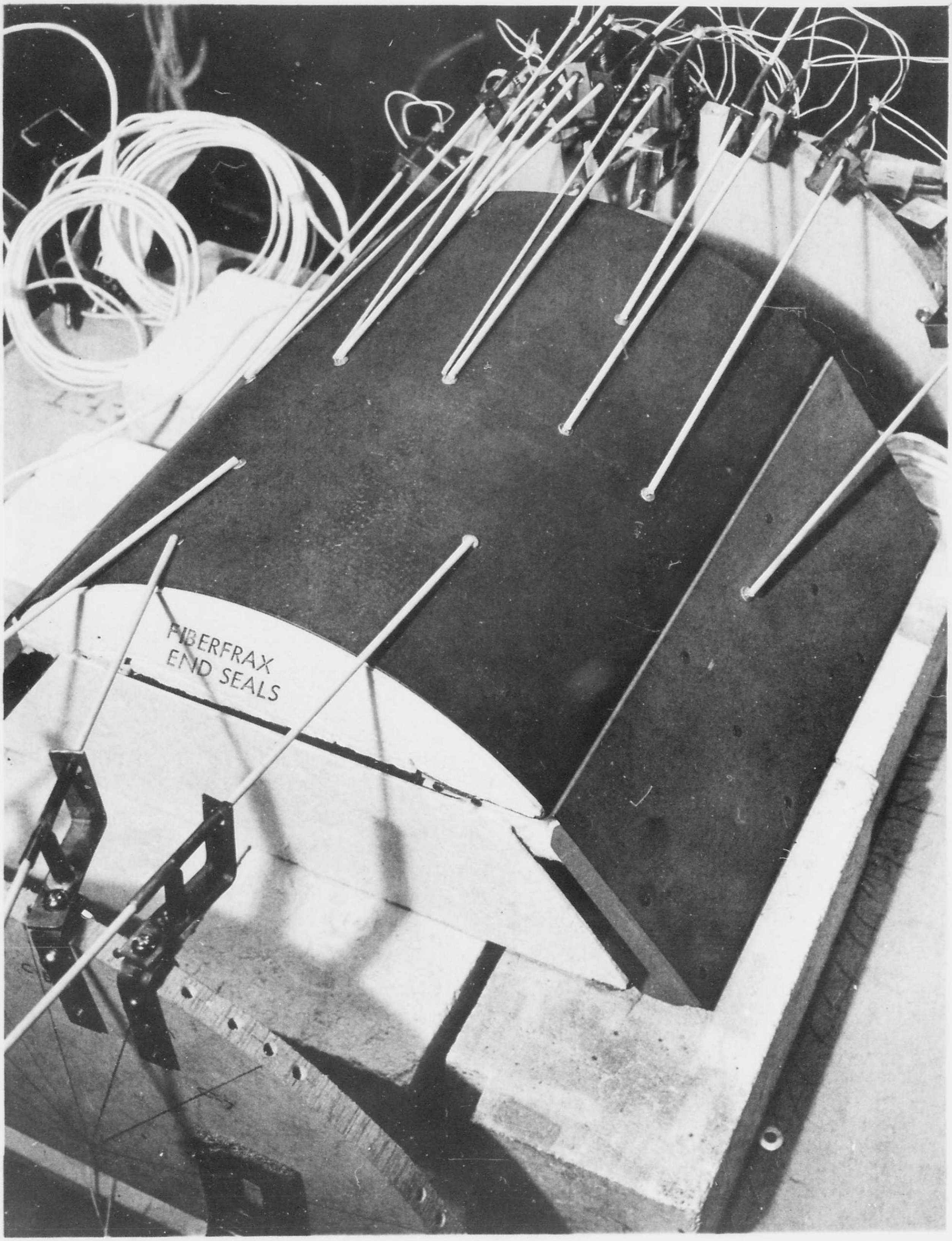
Volume I



25-20372-1 BEFORE HEAT TEST

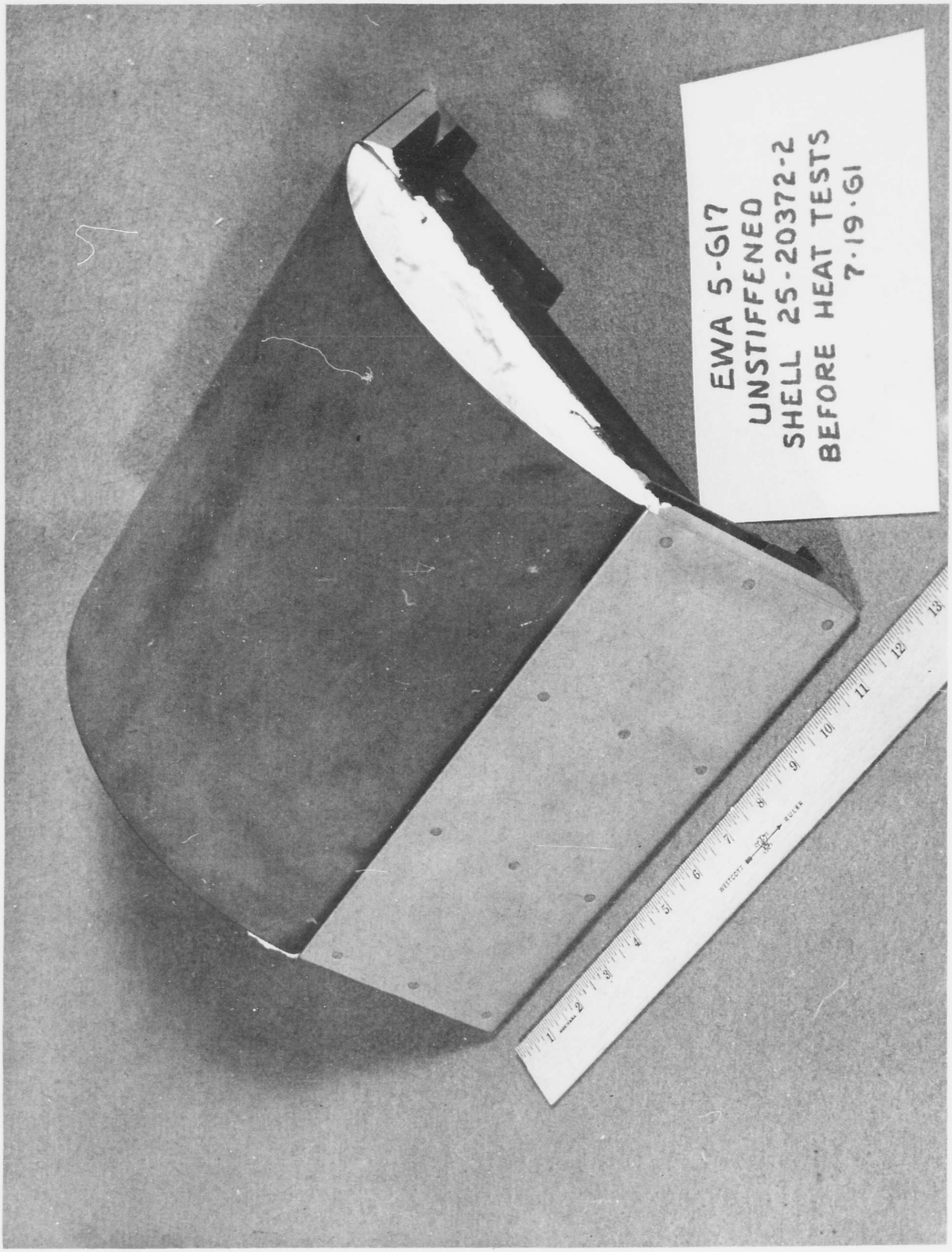
U3-4071-1000 (was BAC 1546-L-R3)

9-3-63

25-20372-1 AFTER HEAT TEST

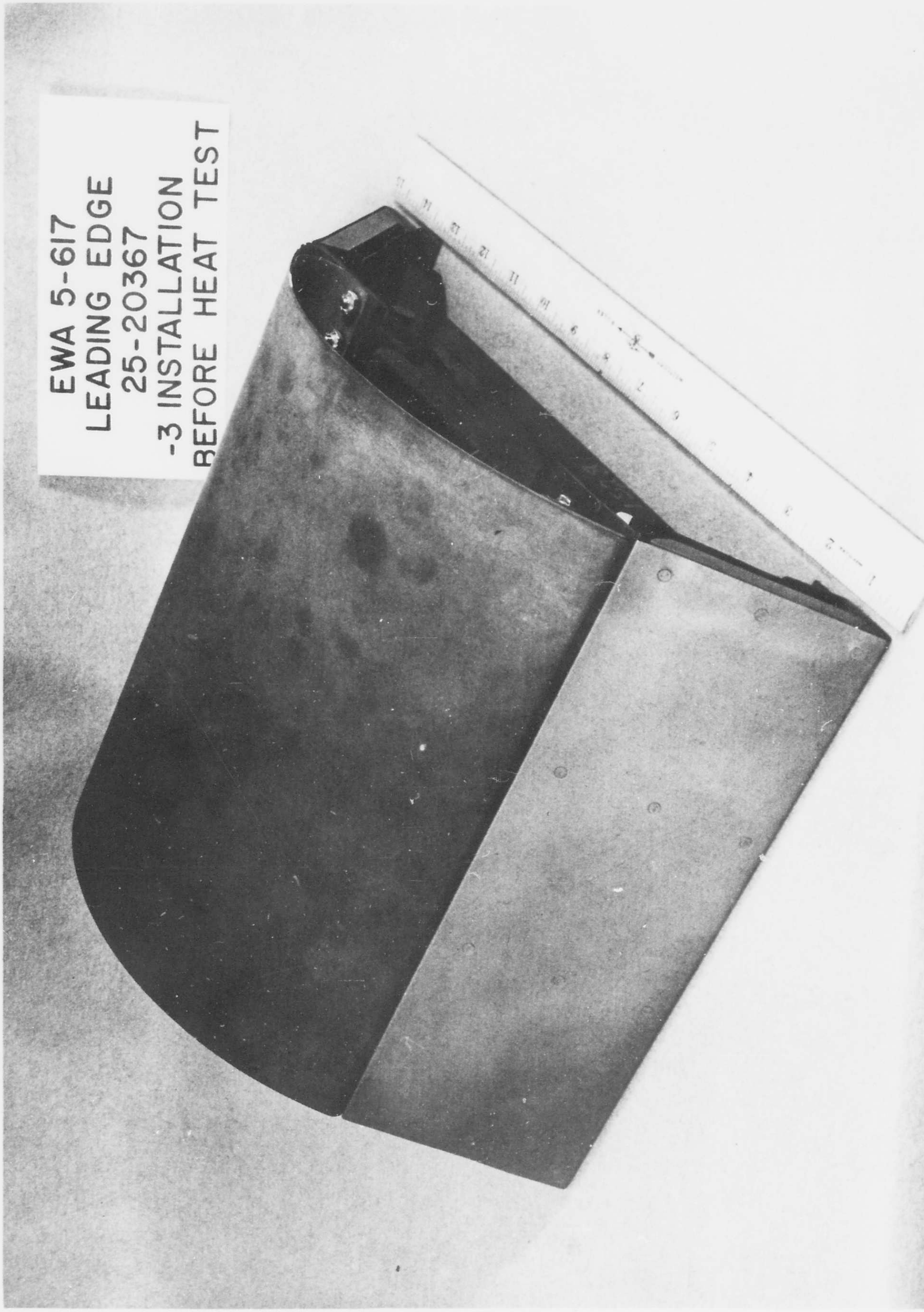
TESTS DS-I 6-21-61

DS-I - EWA 5-617 UNSTIFFENED SHELL 25-20372-2 2A83608
BEFORE HEAT TESTING 7-19-61

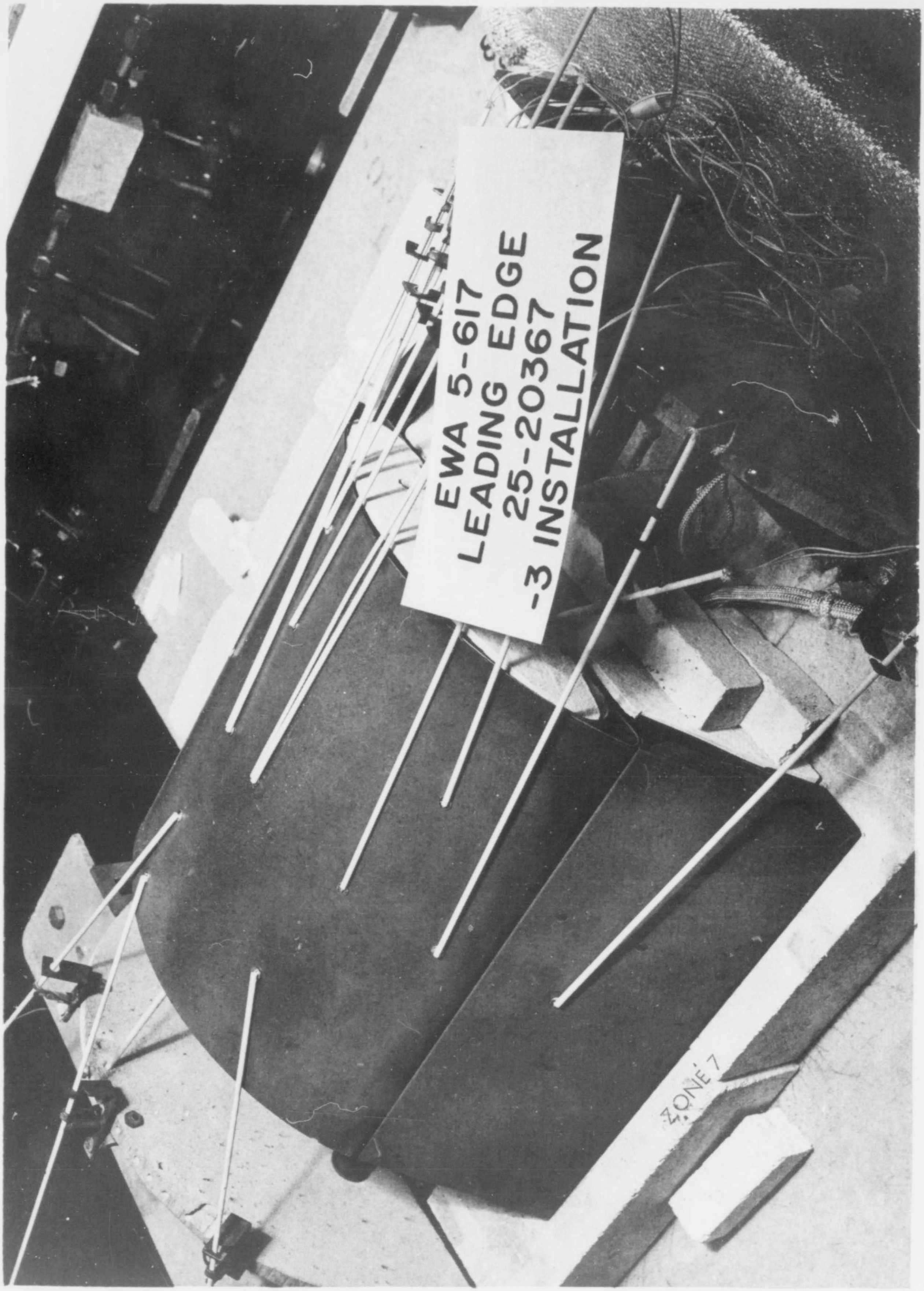


25-20372-2 BEFORE HEAT TEST

25-20372-2 AFTER HEAT TEST

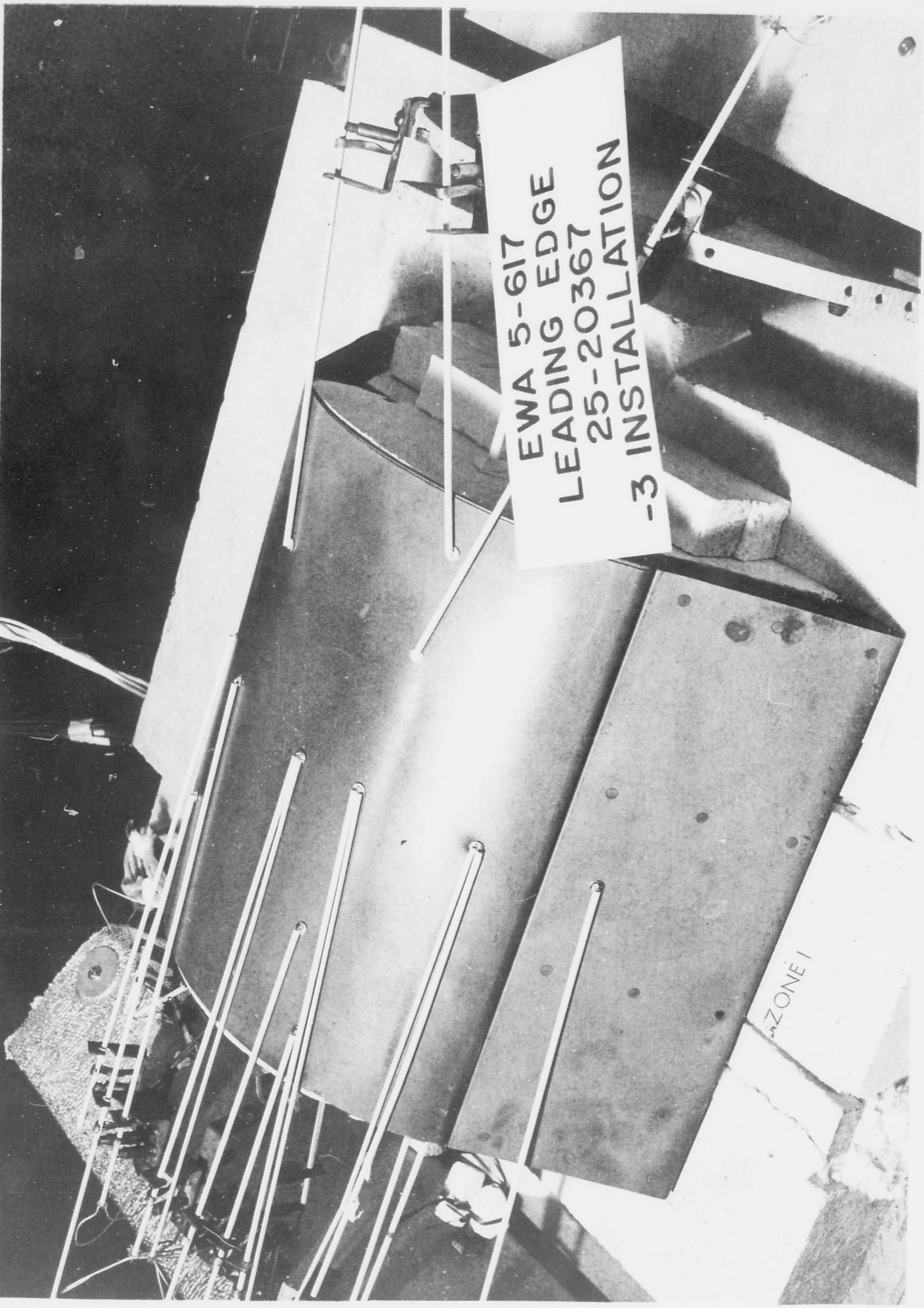


25-20367-1 BEFORE HEAT TEST



25-20367-1 AFTER HEAT TEST

DS-I LEADING EDGE EWA 5617 25-20367-2
-3 INSTALLATION AFTER HEAT TEST 9-29-61
2A89232



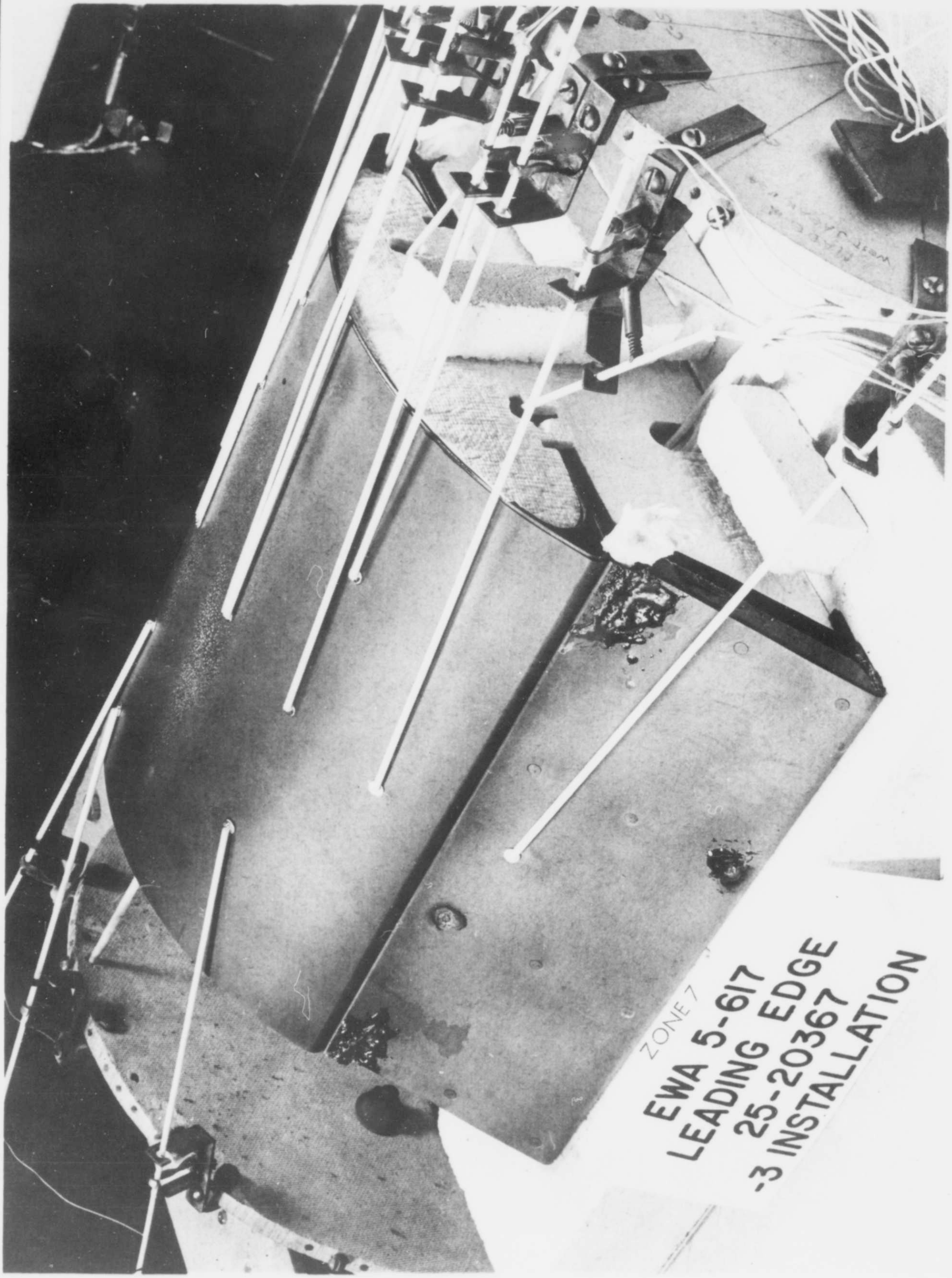
25-20367-I AFTER HEAT TEST

25-20367-2 BEFORE HEAT TEST

-3 INSTALLATION BEFORE HEAT TEST 9-29-61

BAC 1546 L-R3

9-3-63



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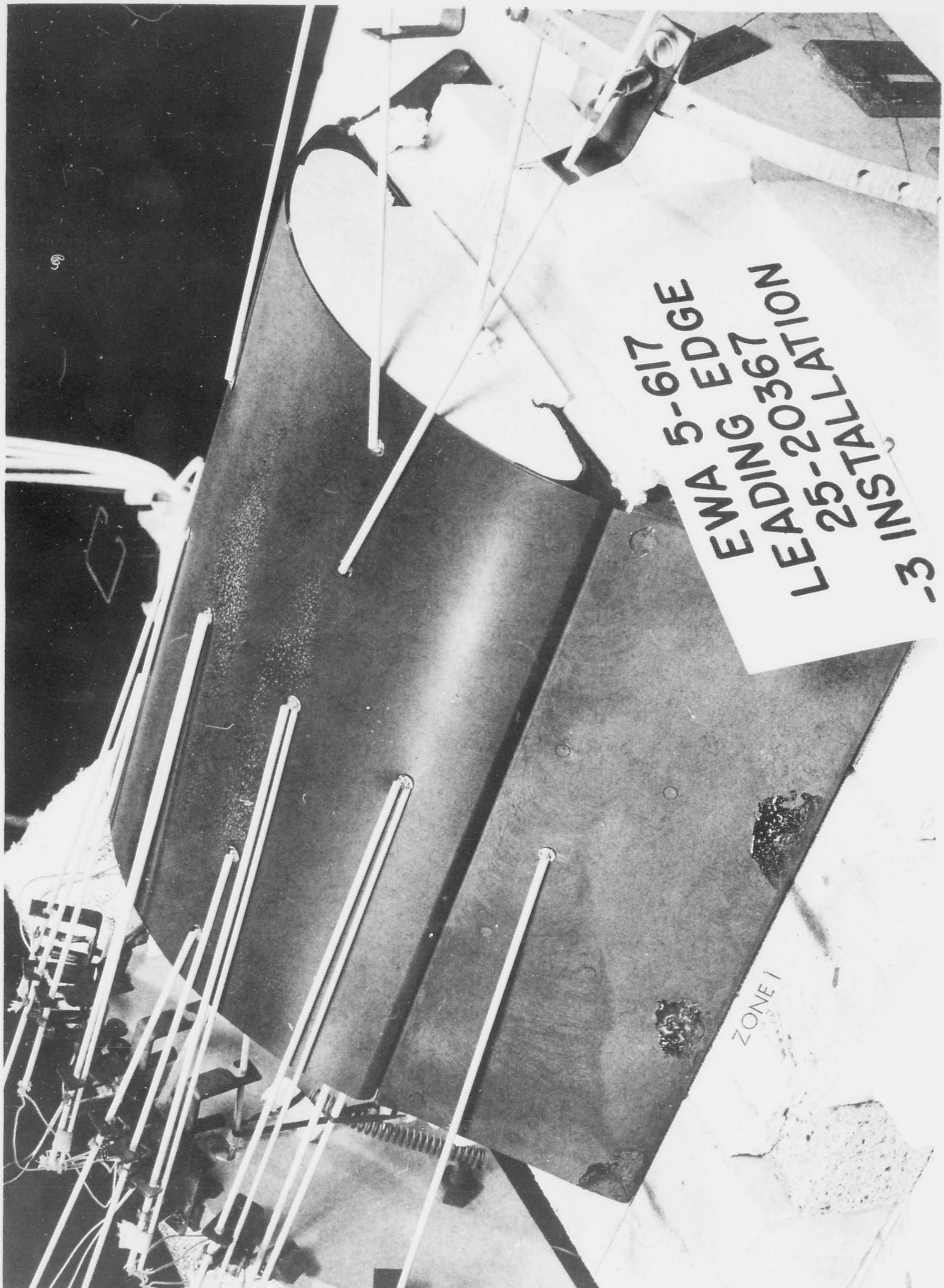
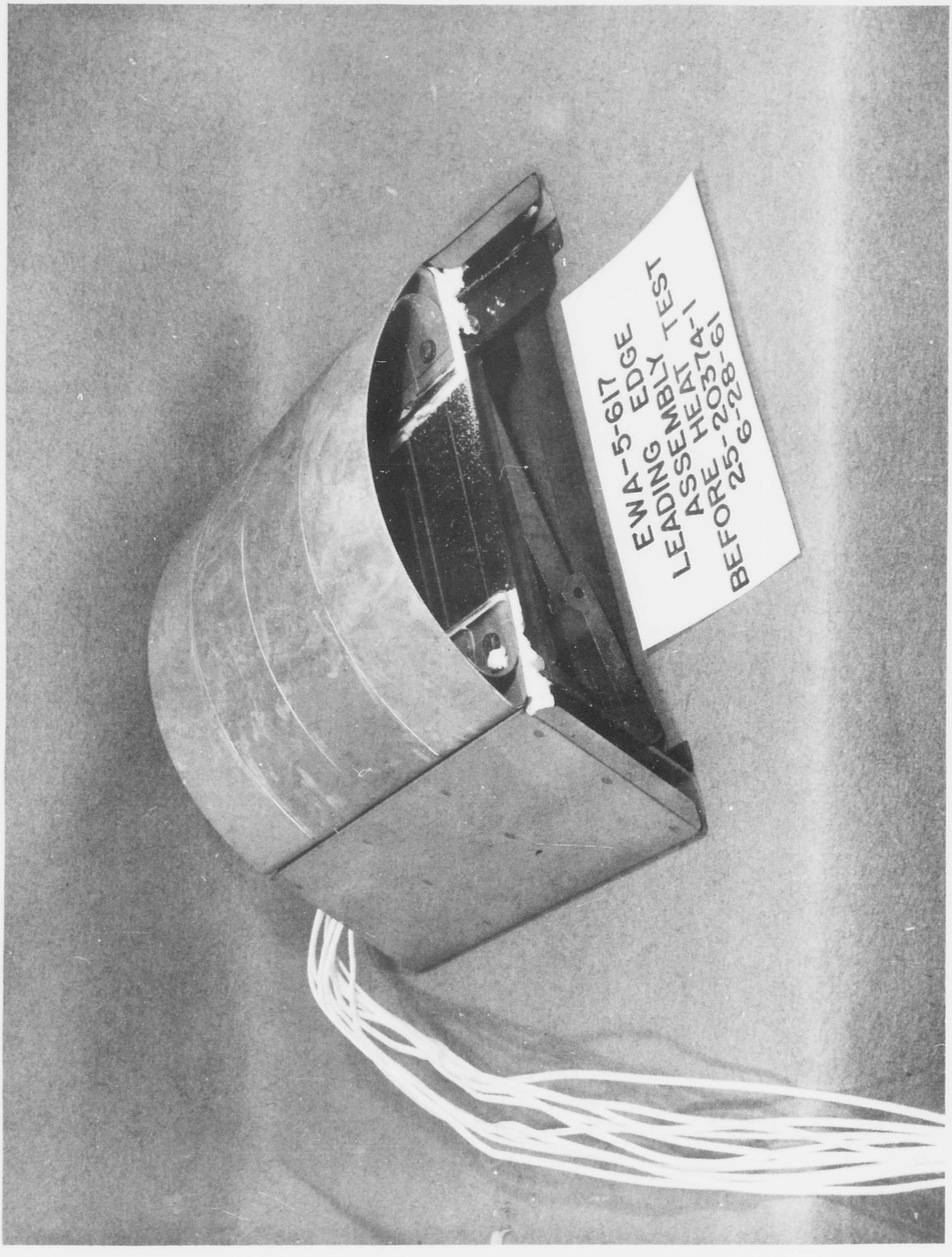
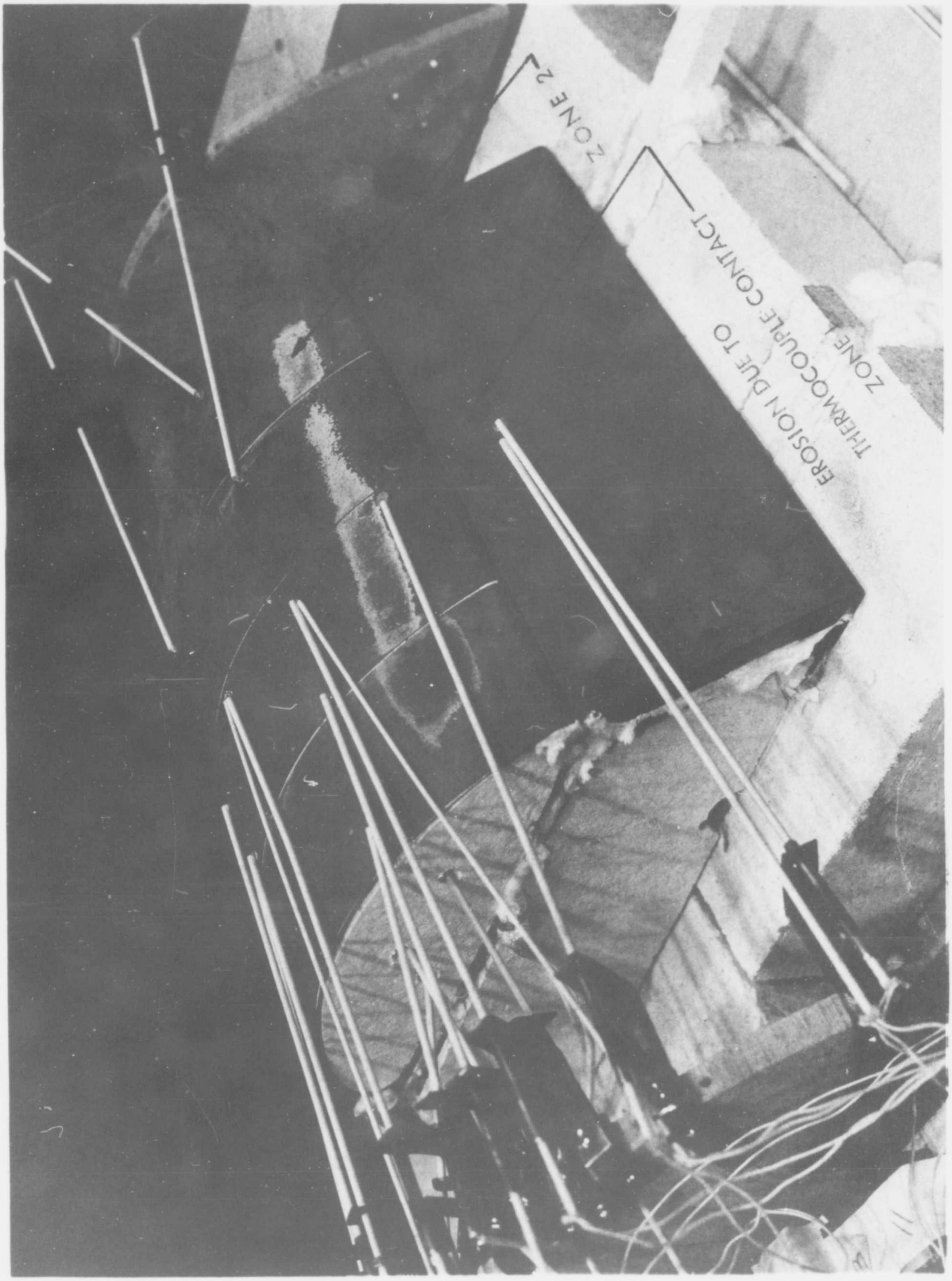


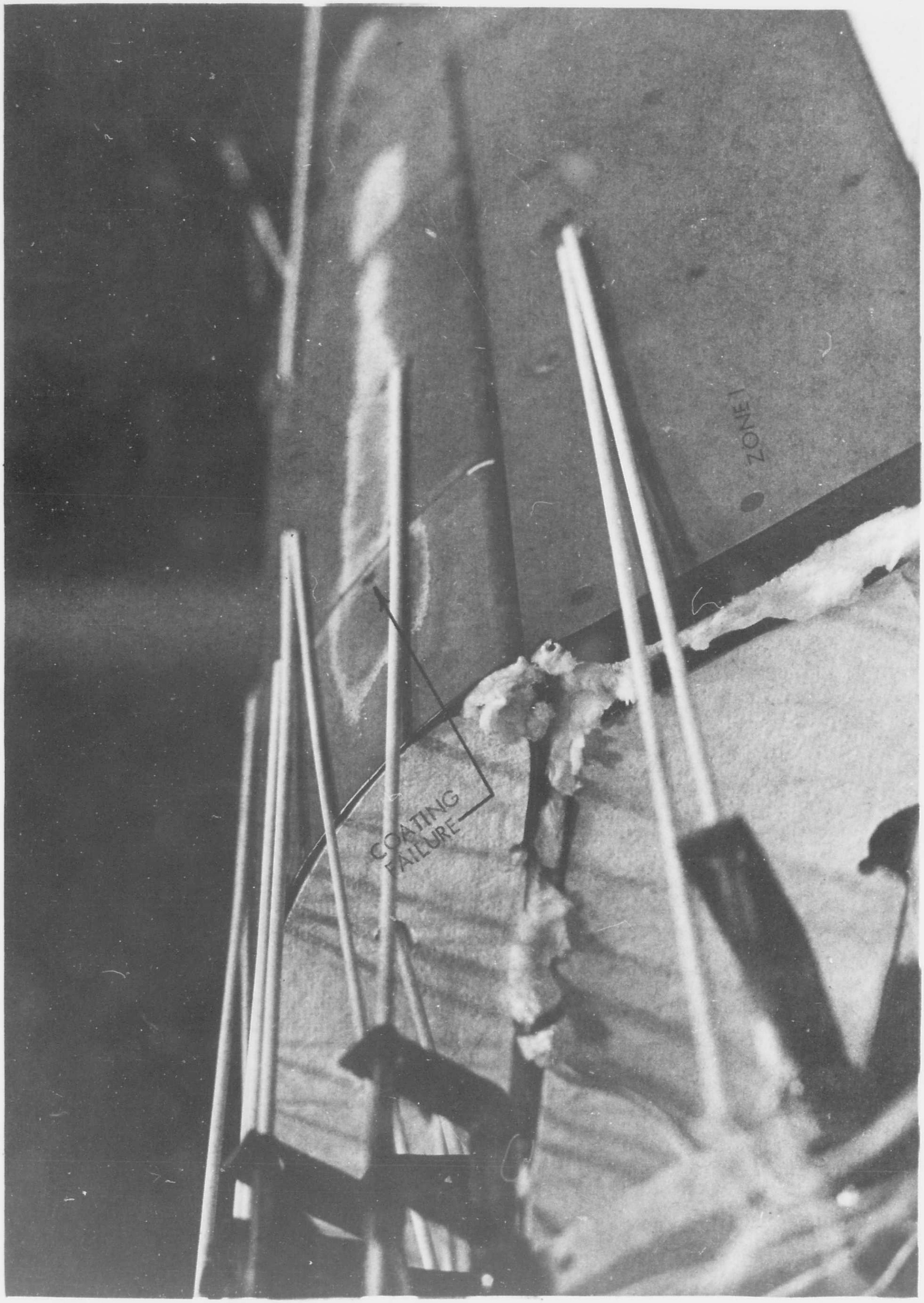
25-20367-2 AFTER HEAT TESTS



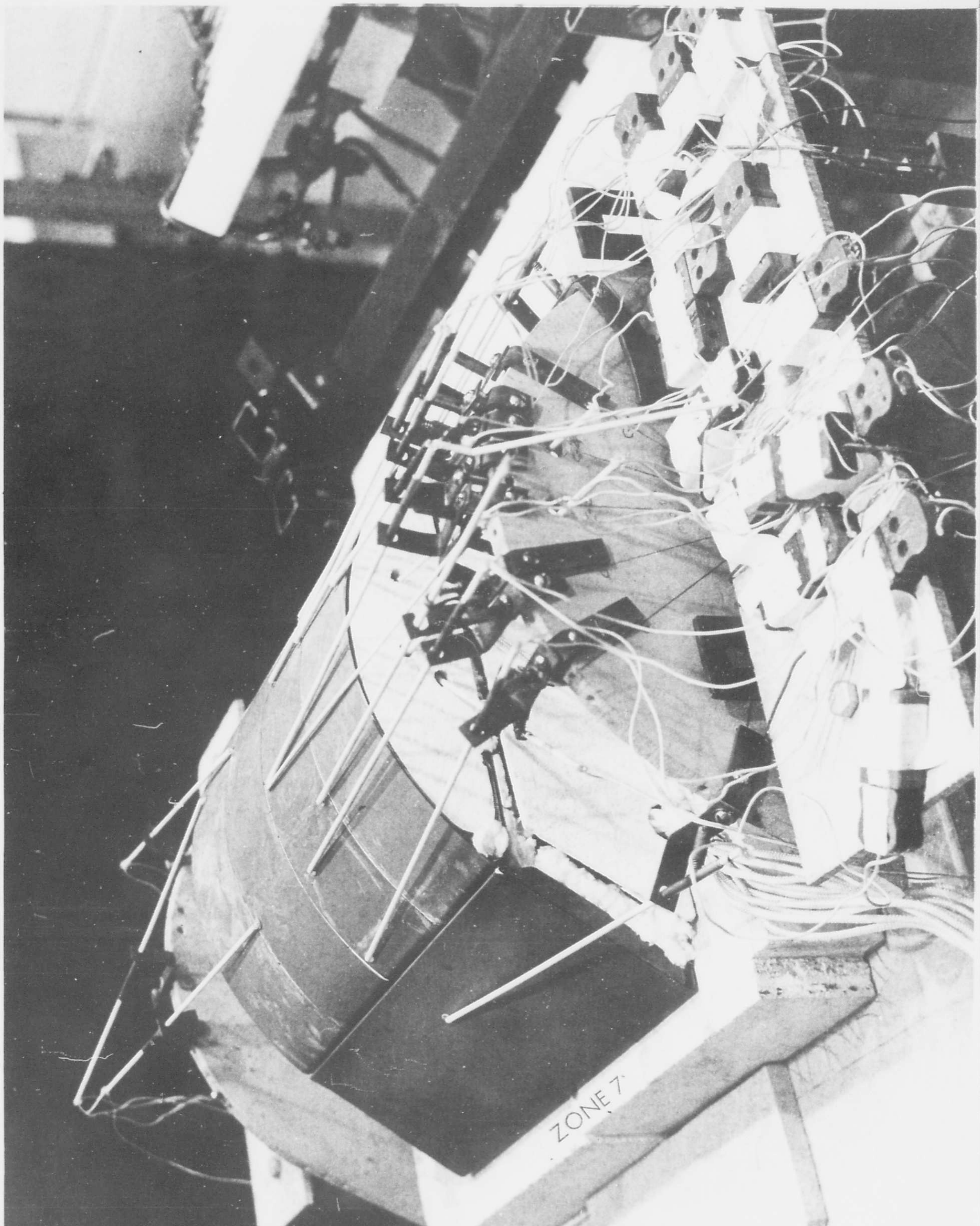
25-20378-I BEFORE HEAT TEST



25-20378-1 AFTER FOUR HEAT CYCLES

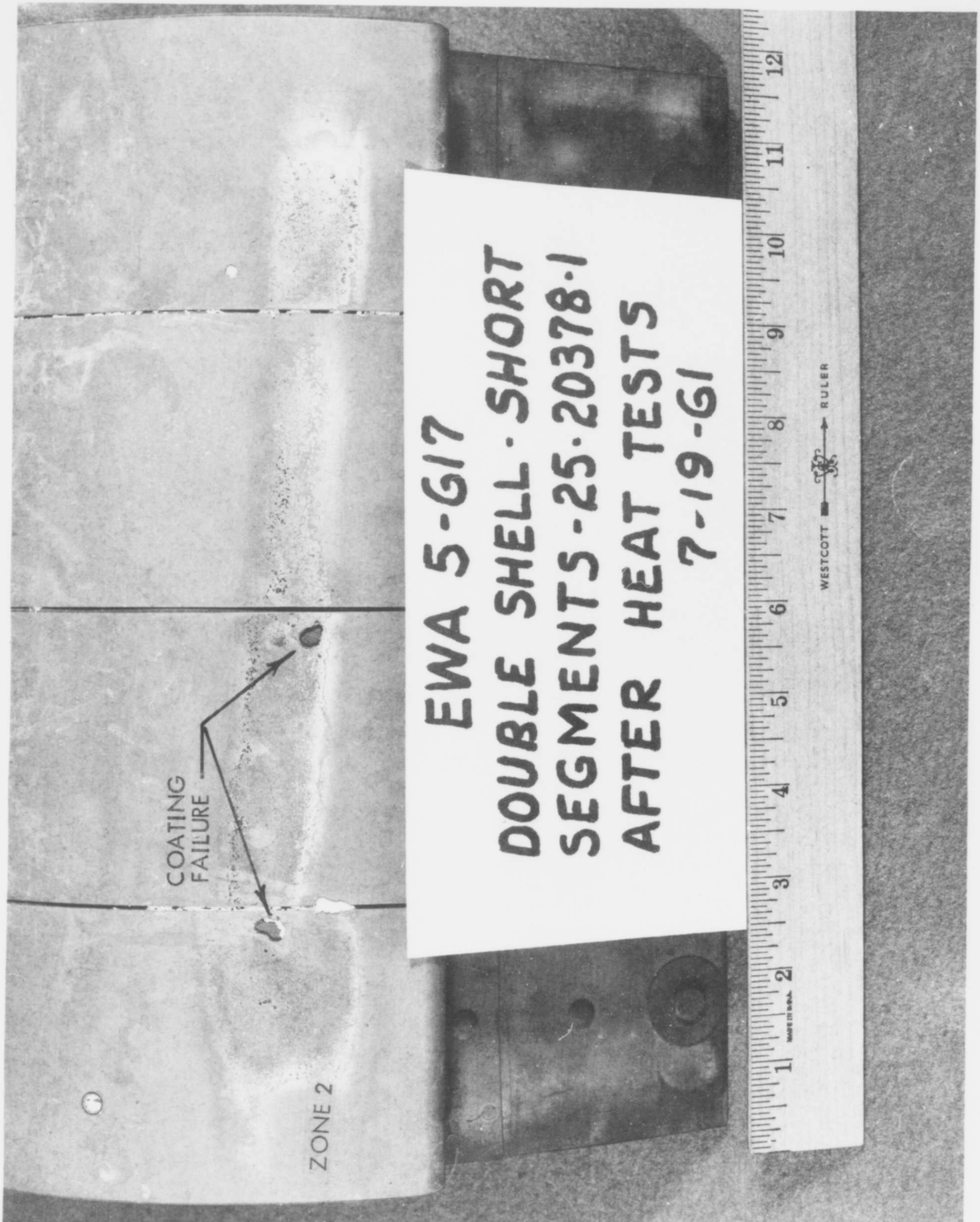


25-20378-I AFTER FOUR HEAT CYCLES

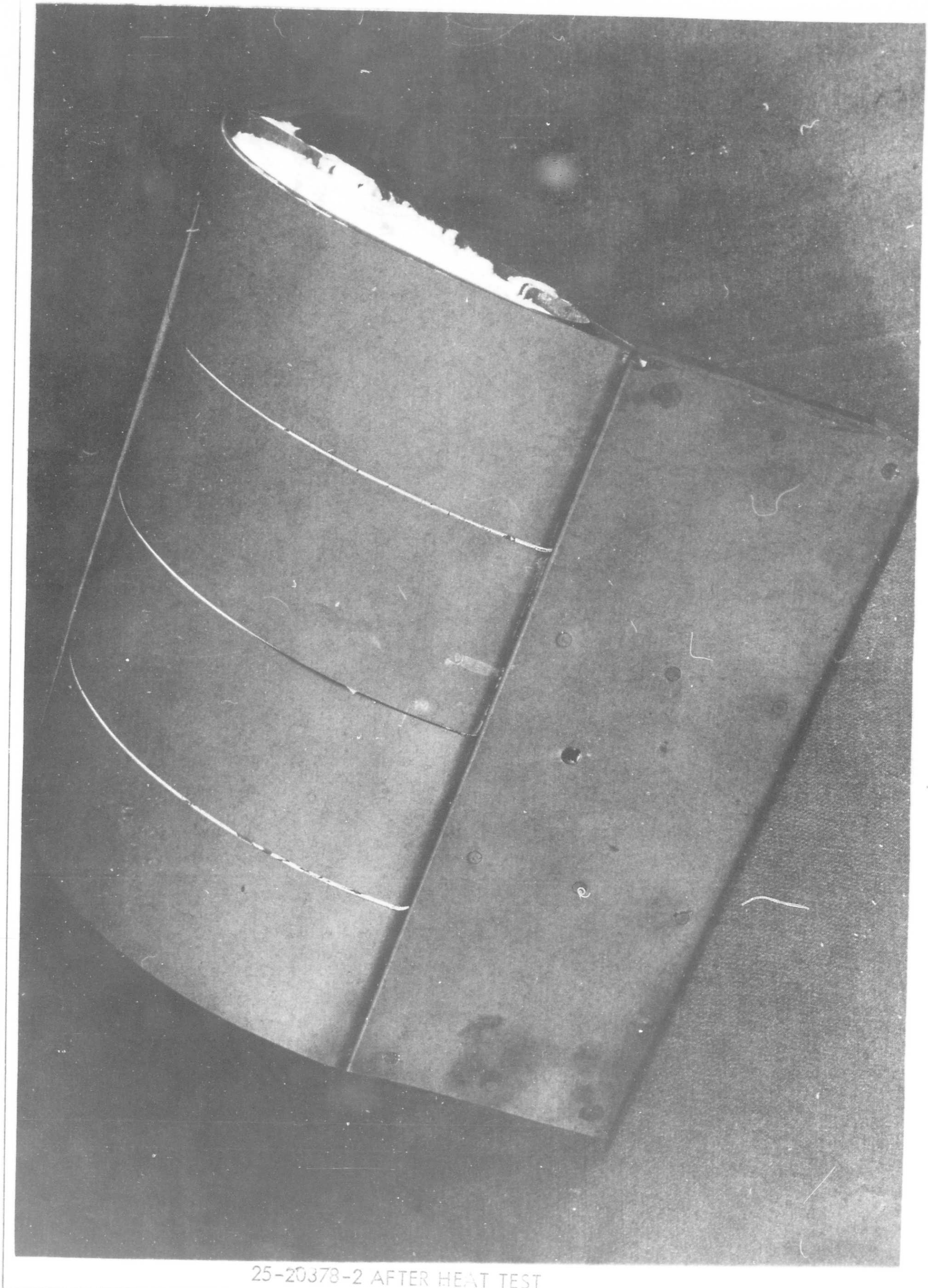


25-20378-1 AFTER FOUR HEAT CYCLES

DS-I - EWA 5-617 DOUBLE SHELL - SHORT SEGMENTS 2A83609
25-20378-1 AFTER HEAT TESTING 7-19-61



25-20378-1 AFTER HEAT TESTS



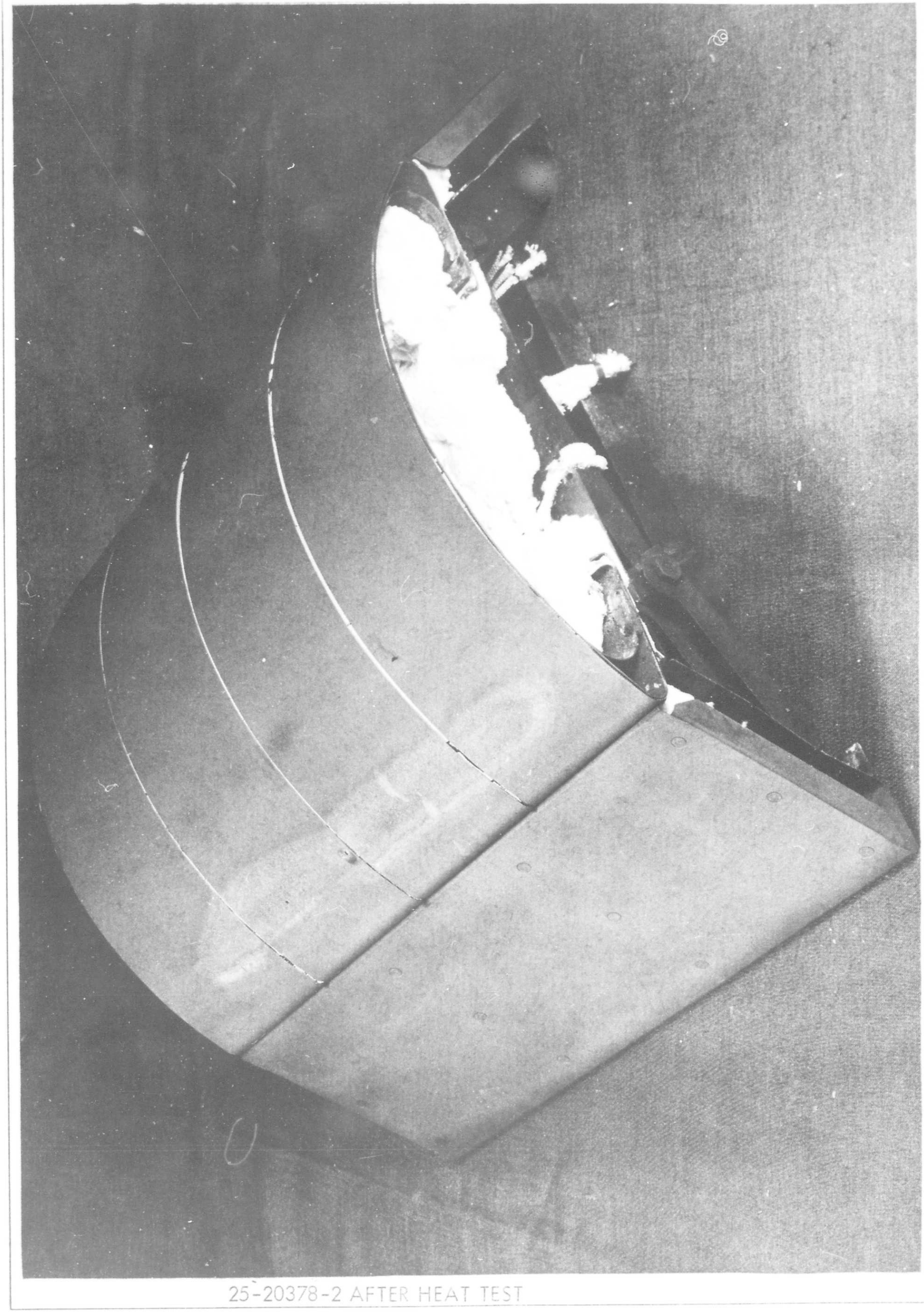
25-20378-2 AFTER HEAT TEST

U3-4071-1000 (was BAC 1546-L-R3)

9-3-63

Volume II

DYNASOAR LEADING EDGE EWA 5617 25-20378-6 2A86355
INSTALLATION AFTER HEAT TEST 8-8-61



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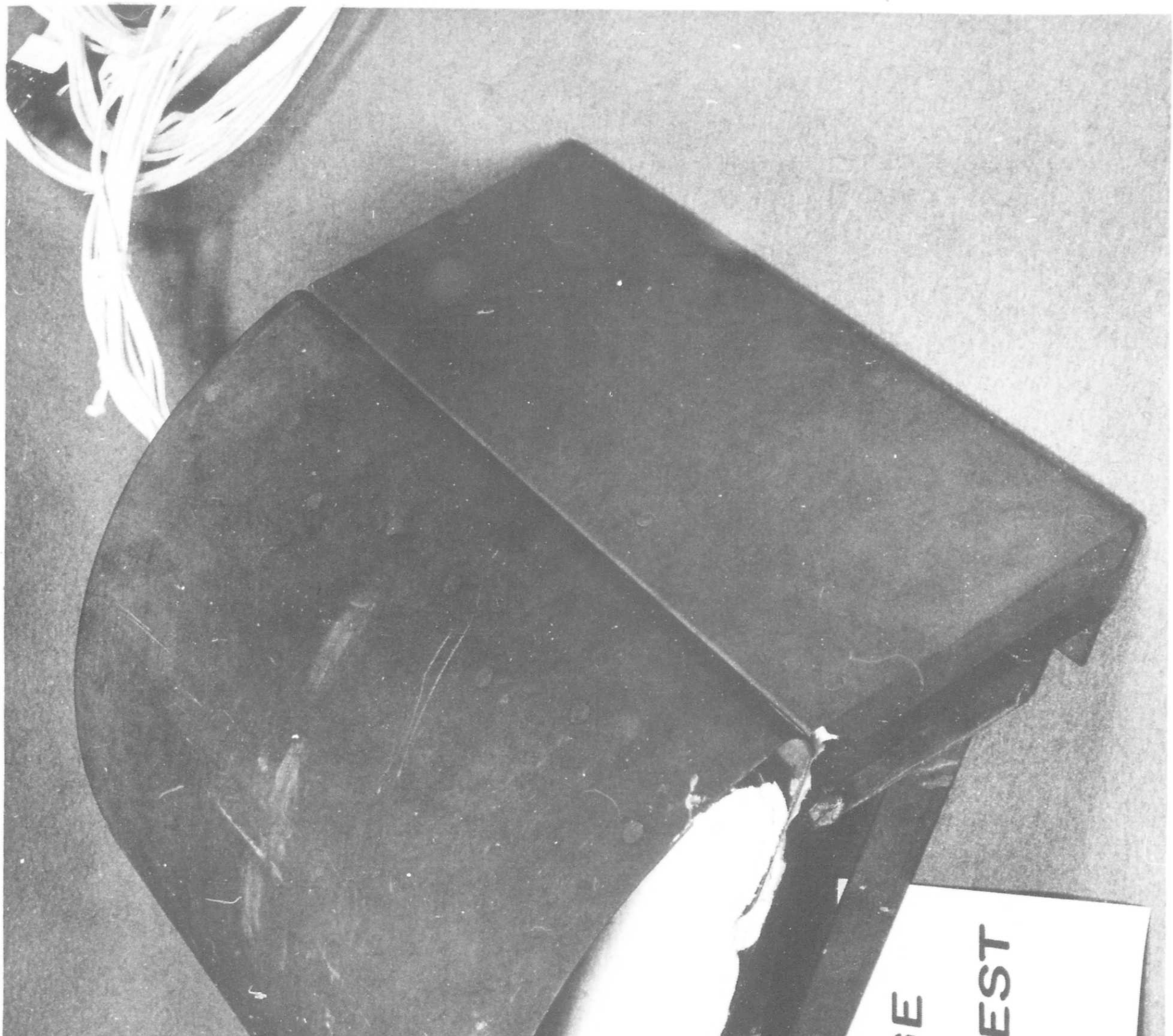
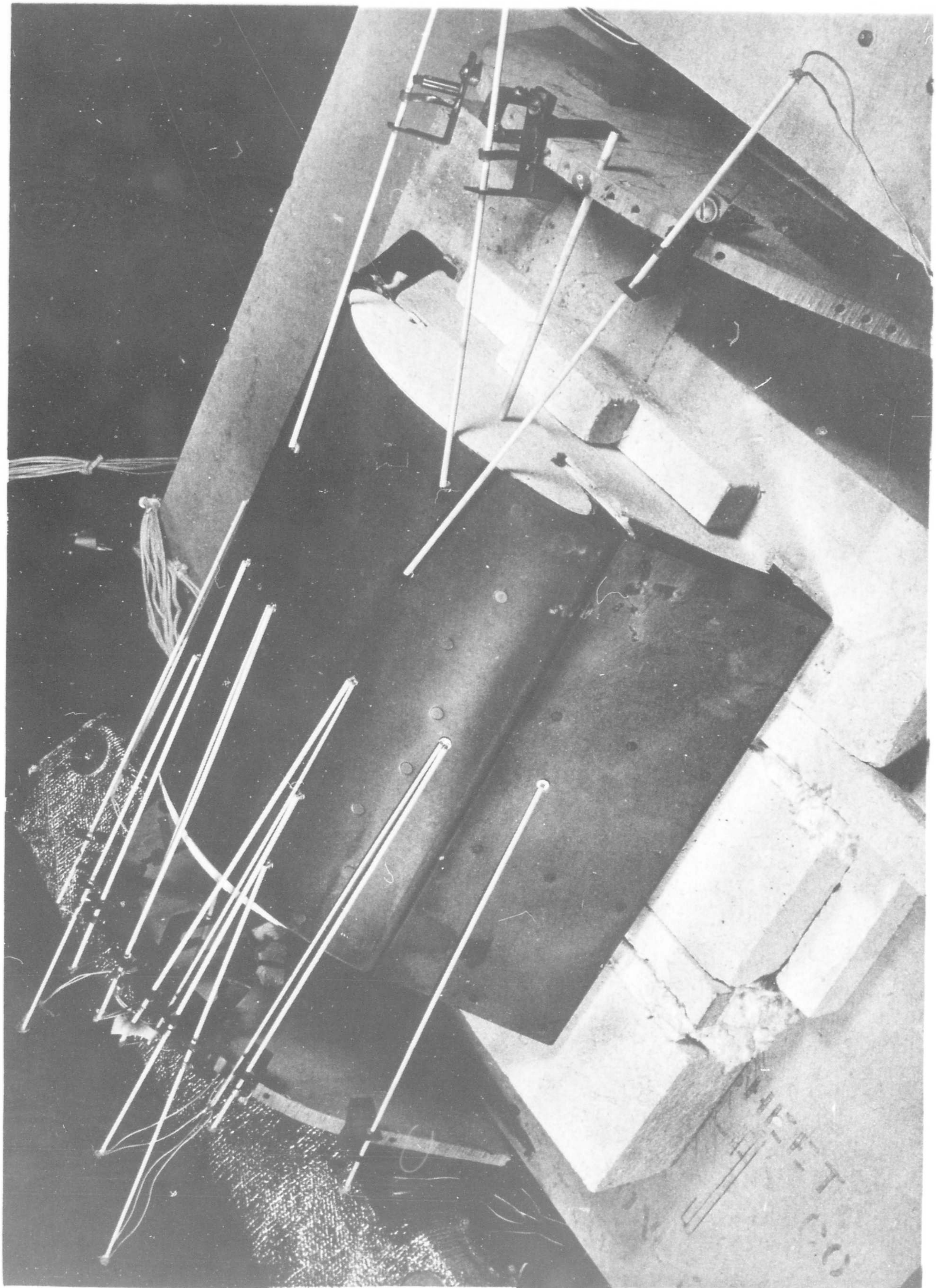


25-20341-1 BEFORE HEAT TEST



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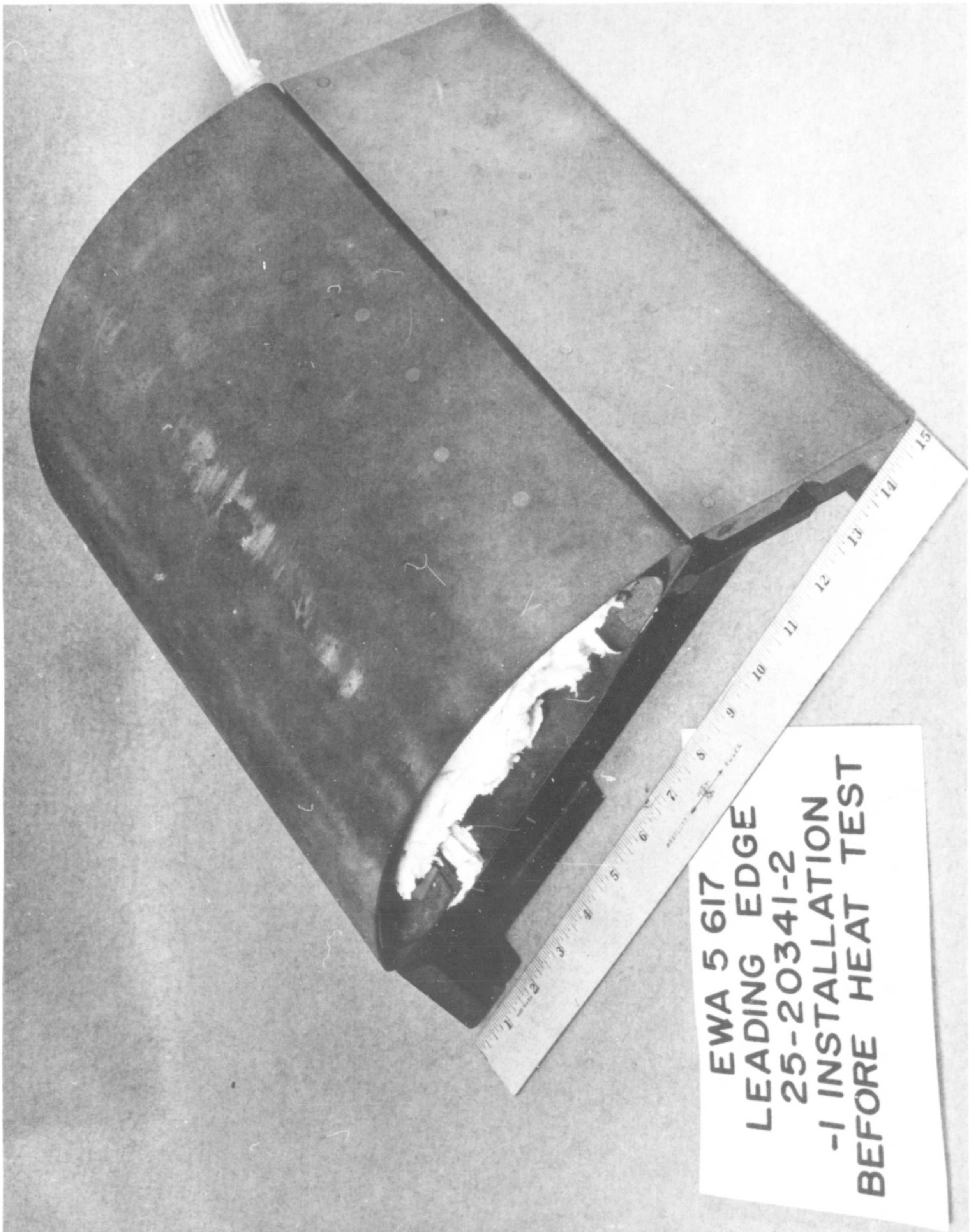
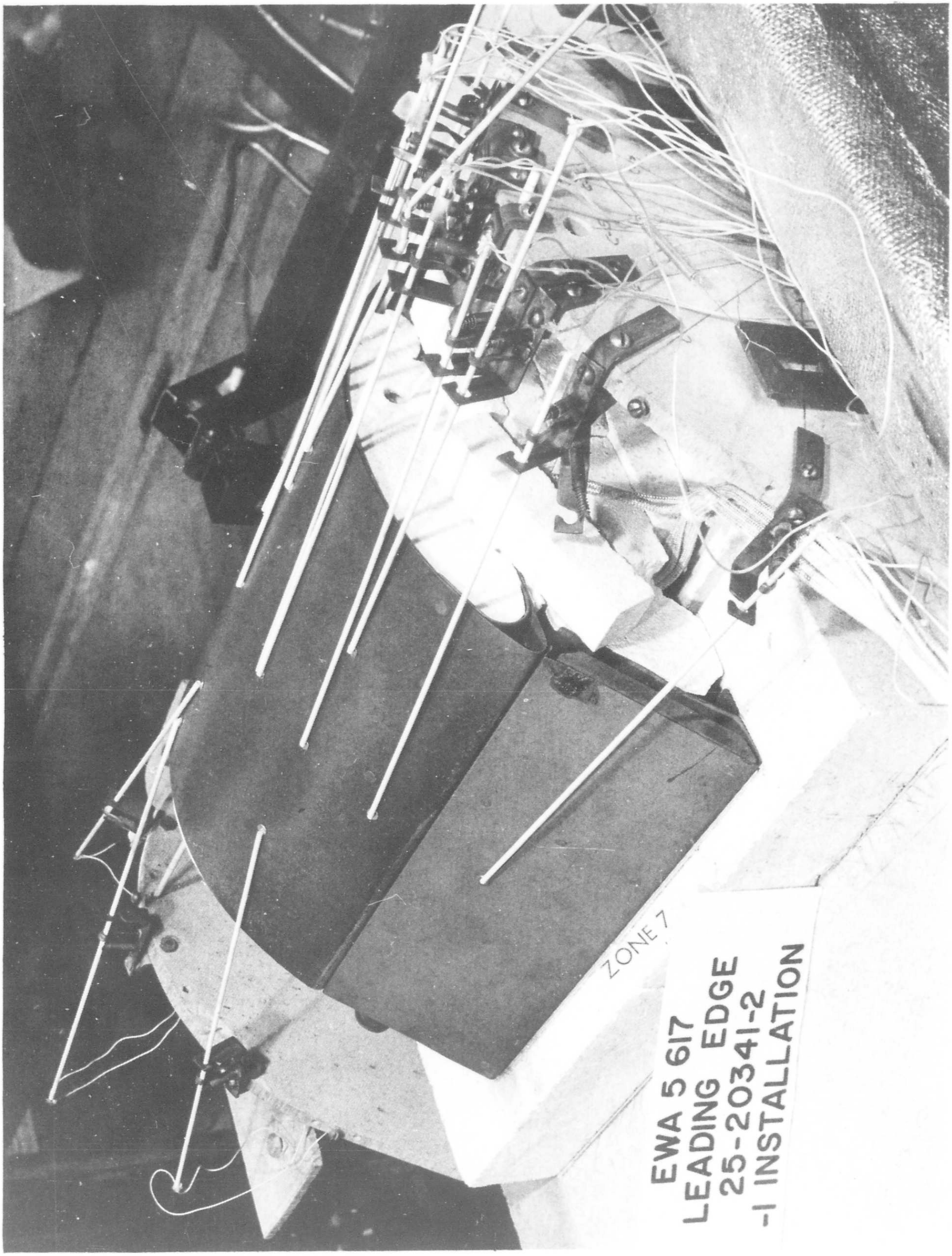


25-20341-2 BEFORE HEAT TEST

INSTALLATION AFTER HEAT TEST 10-12-61

25-20341-2 AFTER HEAT TEST



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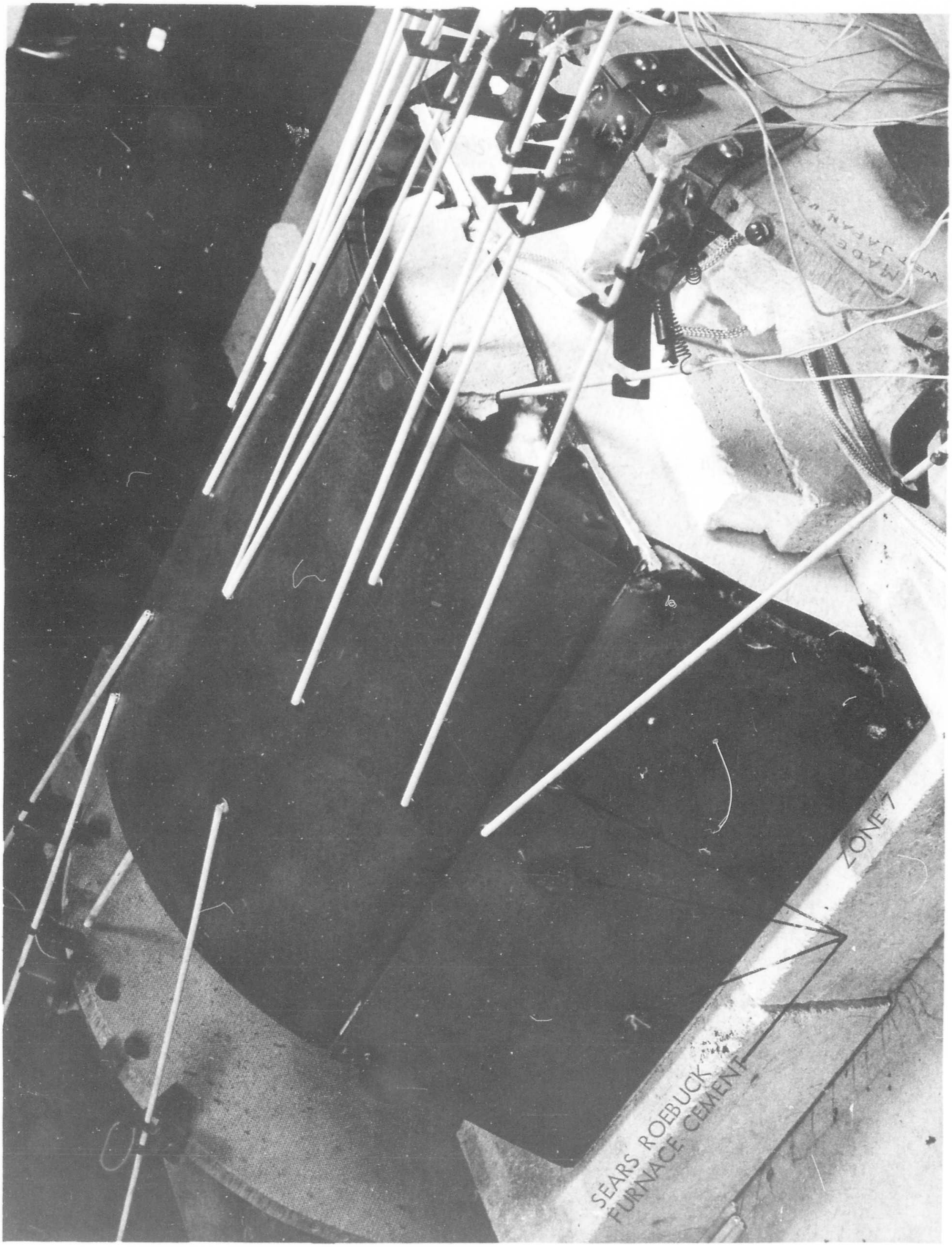
25-20376-1 BEFORE HEAT TEST



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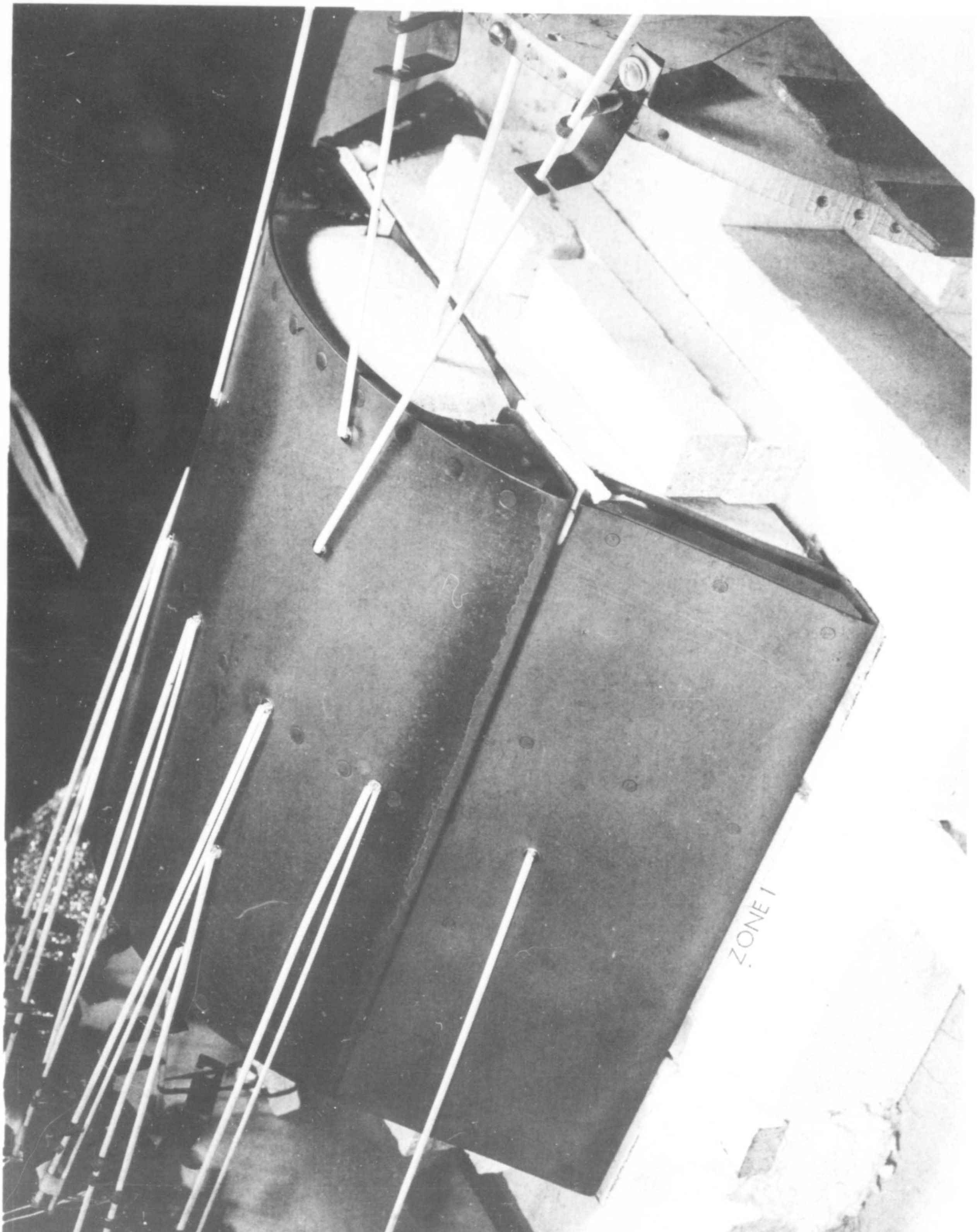
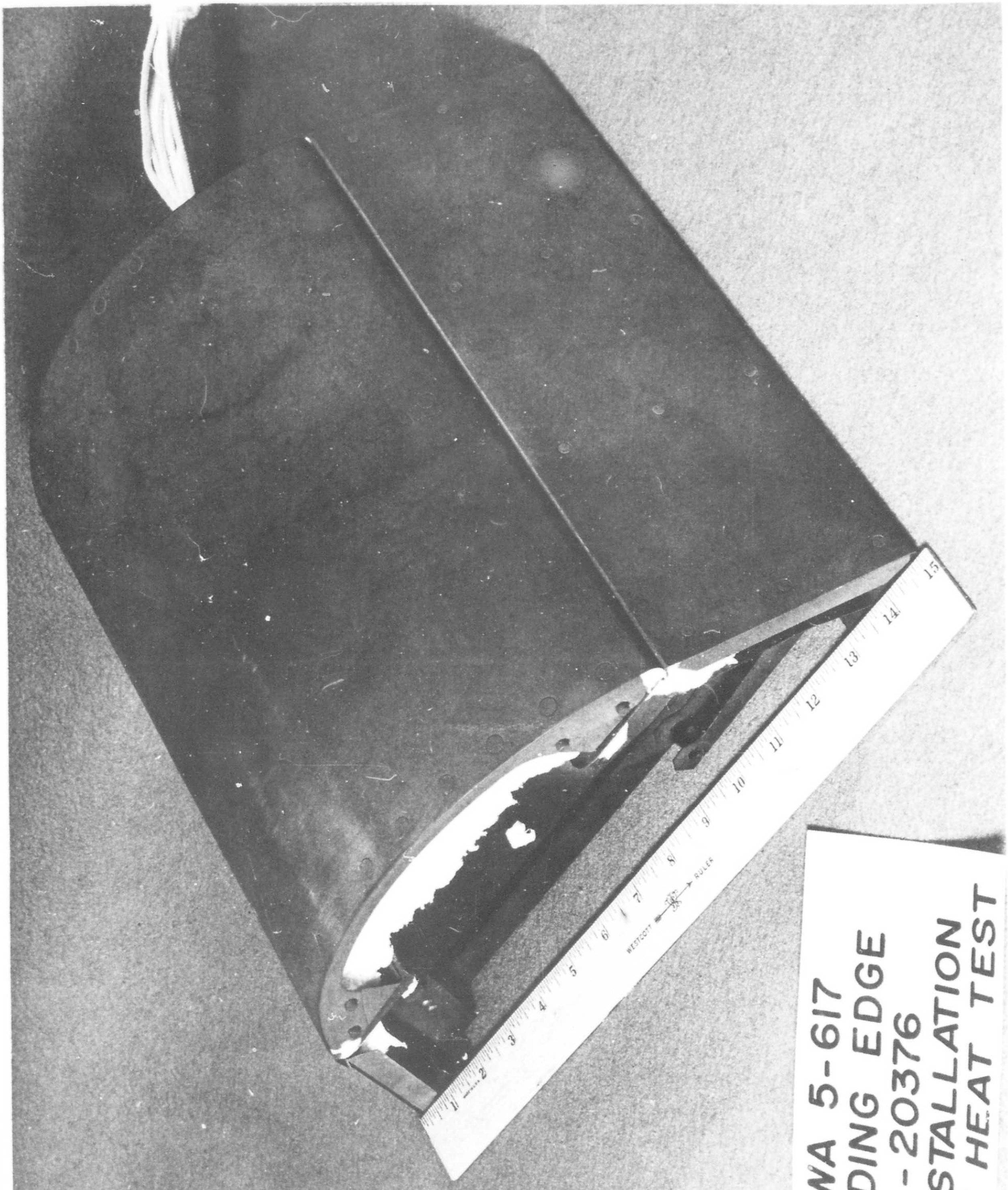


25-20376-1 AFTER HEAT TEST

AFTER HEAT TEST 8-28-61

DYNASOAR LEADING EDGE EWA 5-617 - INSTALLATION 2A88169
BEFORE HEAT TEST 9-11-61



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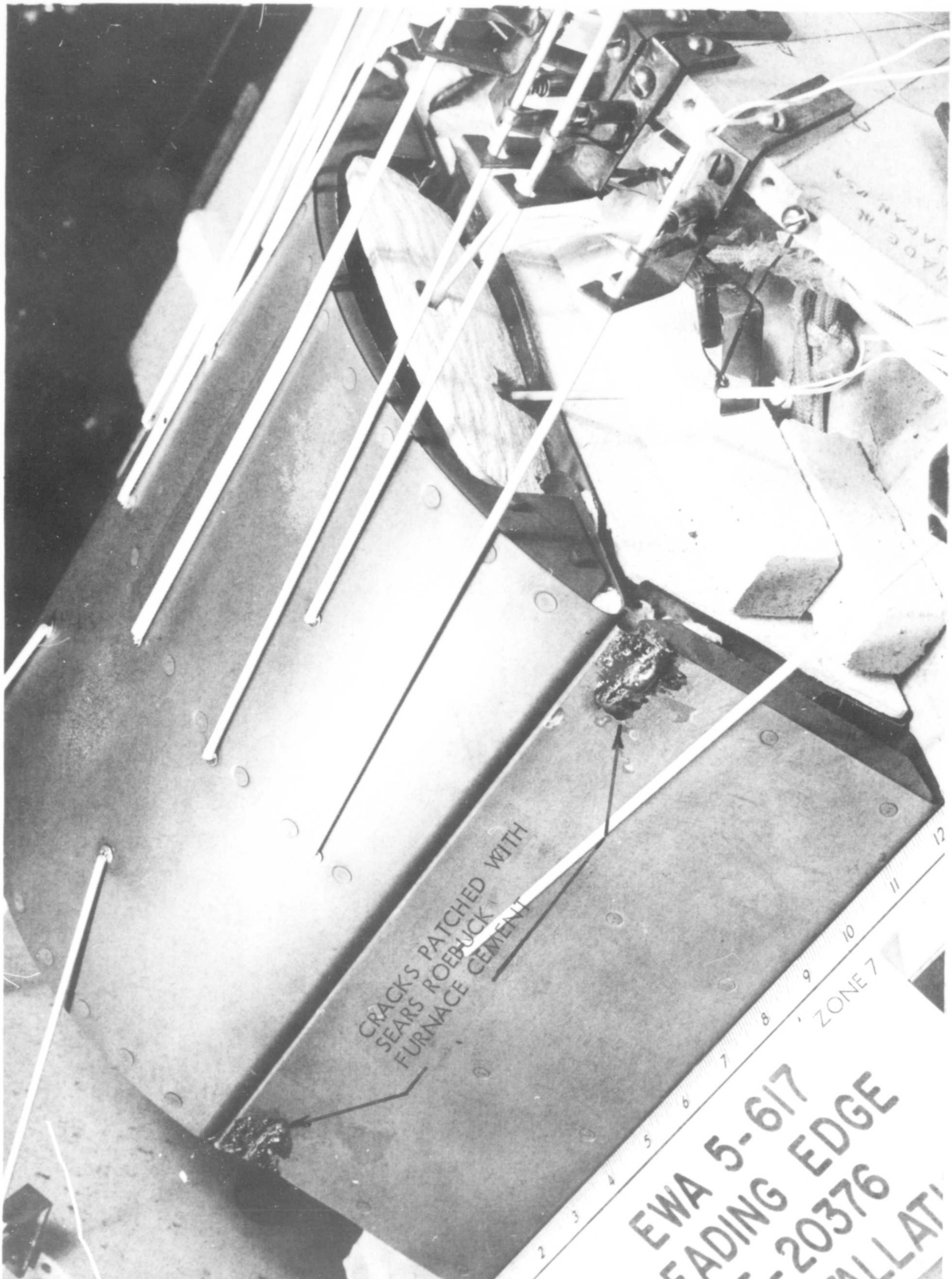


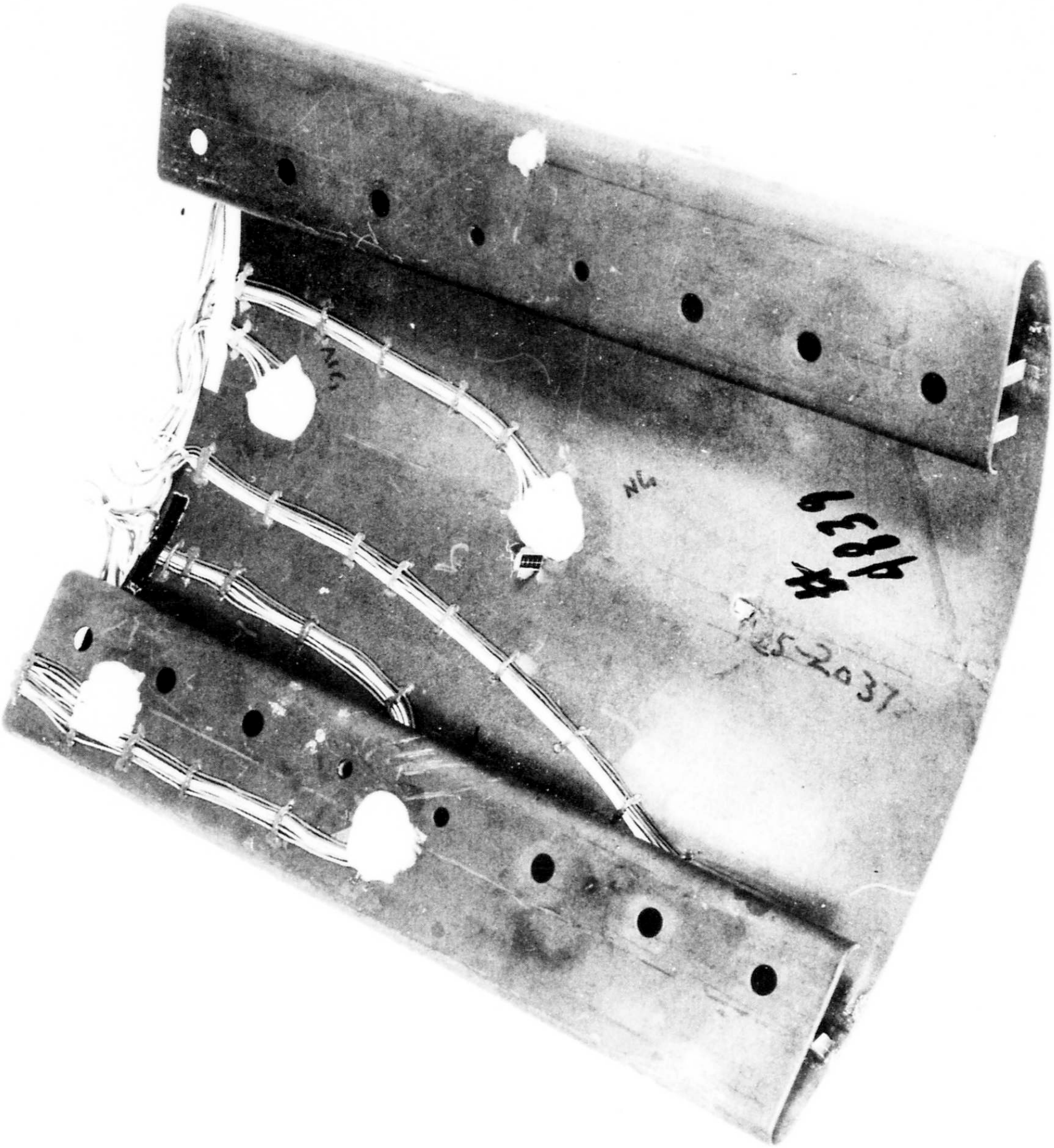
25-20376-2 AFTER HEAT TEST

25-20376-2 AFTER HEAT TEST

1-17-62

#25-20372

25-20372-1 SLOW-LOAD TESTED



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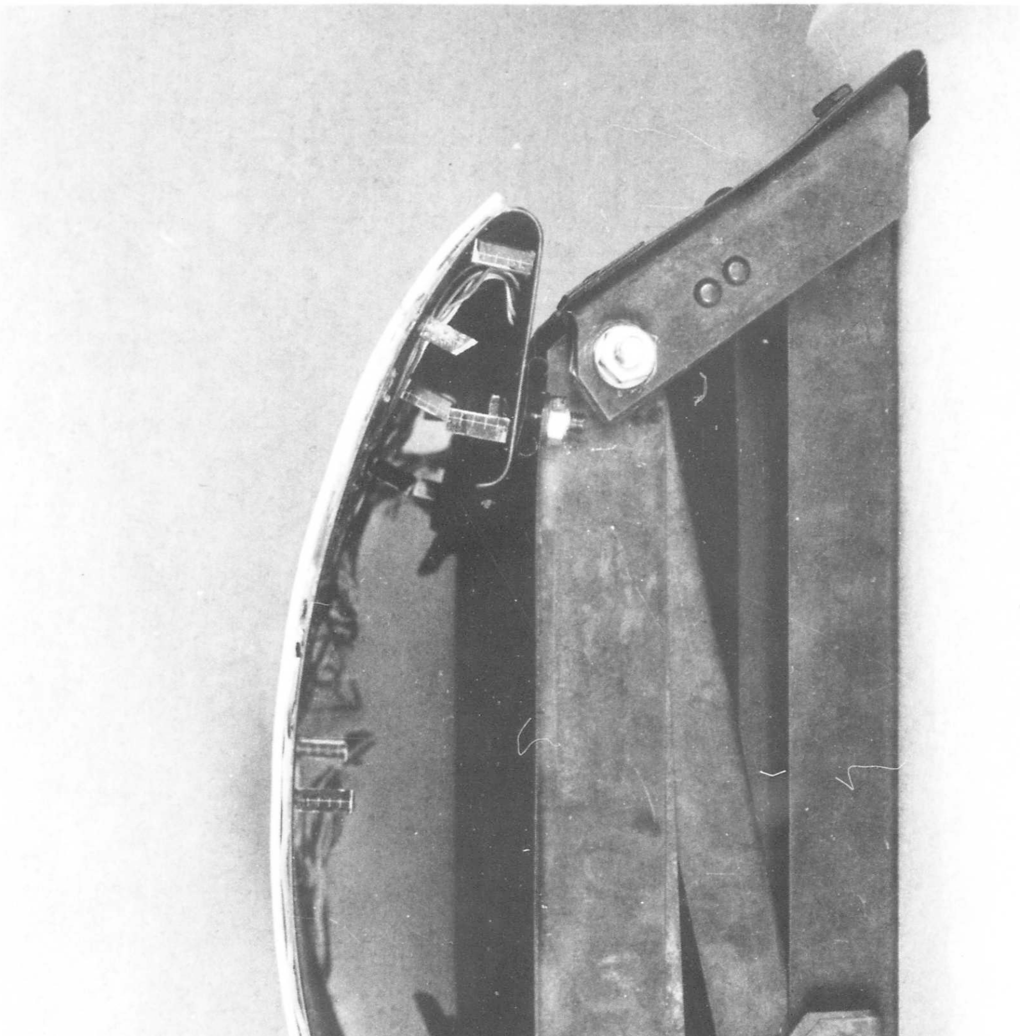
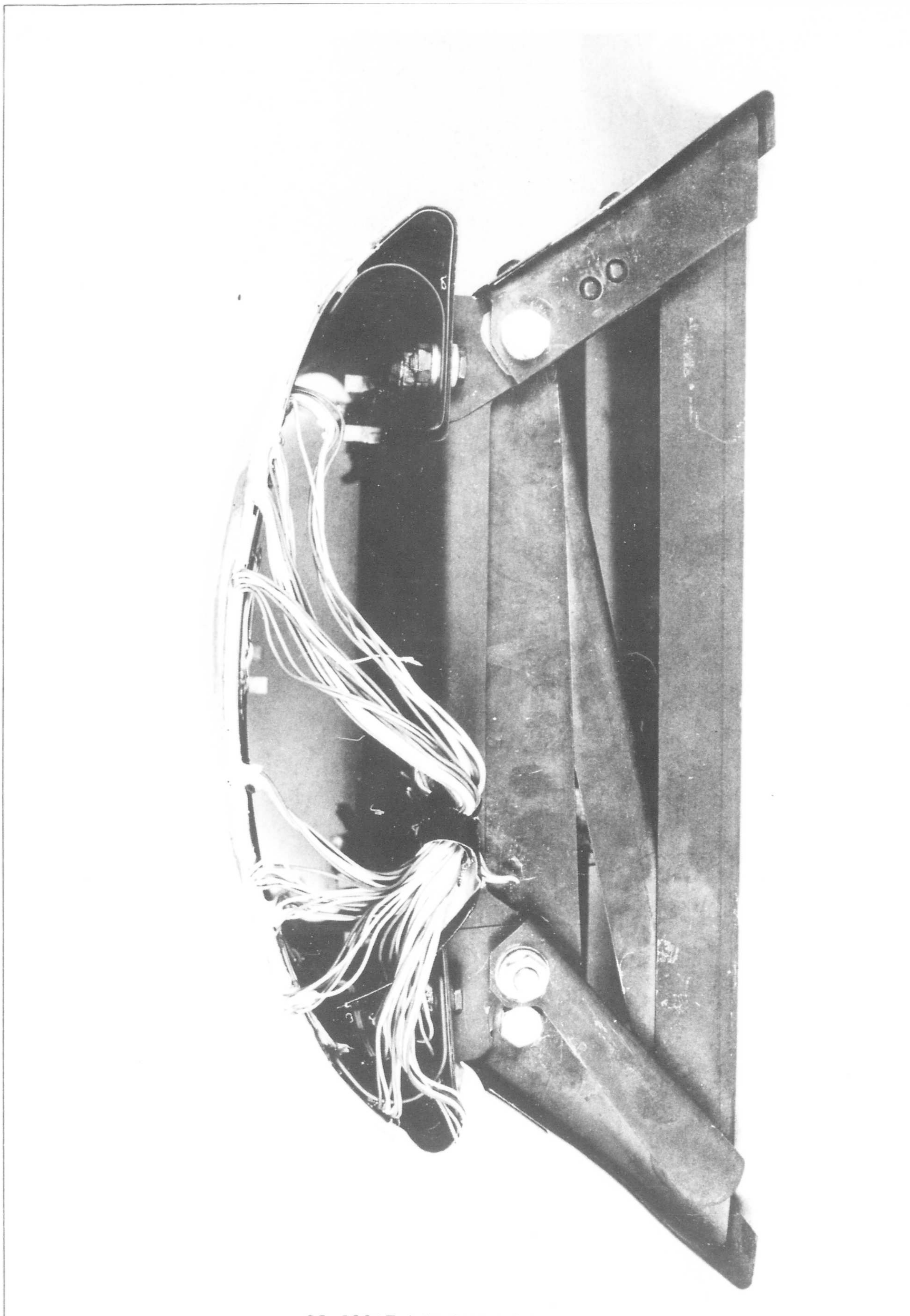


25-20372-1 SLOW-LOAD TESTED

1-17-62

#25-20372

DS-I LEADING EDGE FAILURES
#25-20367
1-17-62
2A96278



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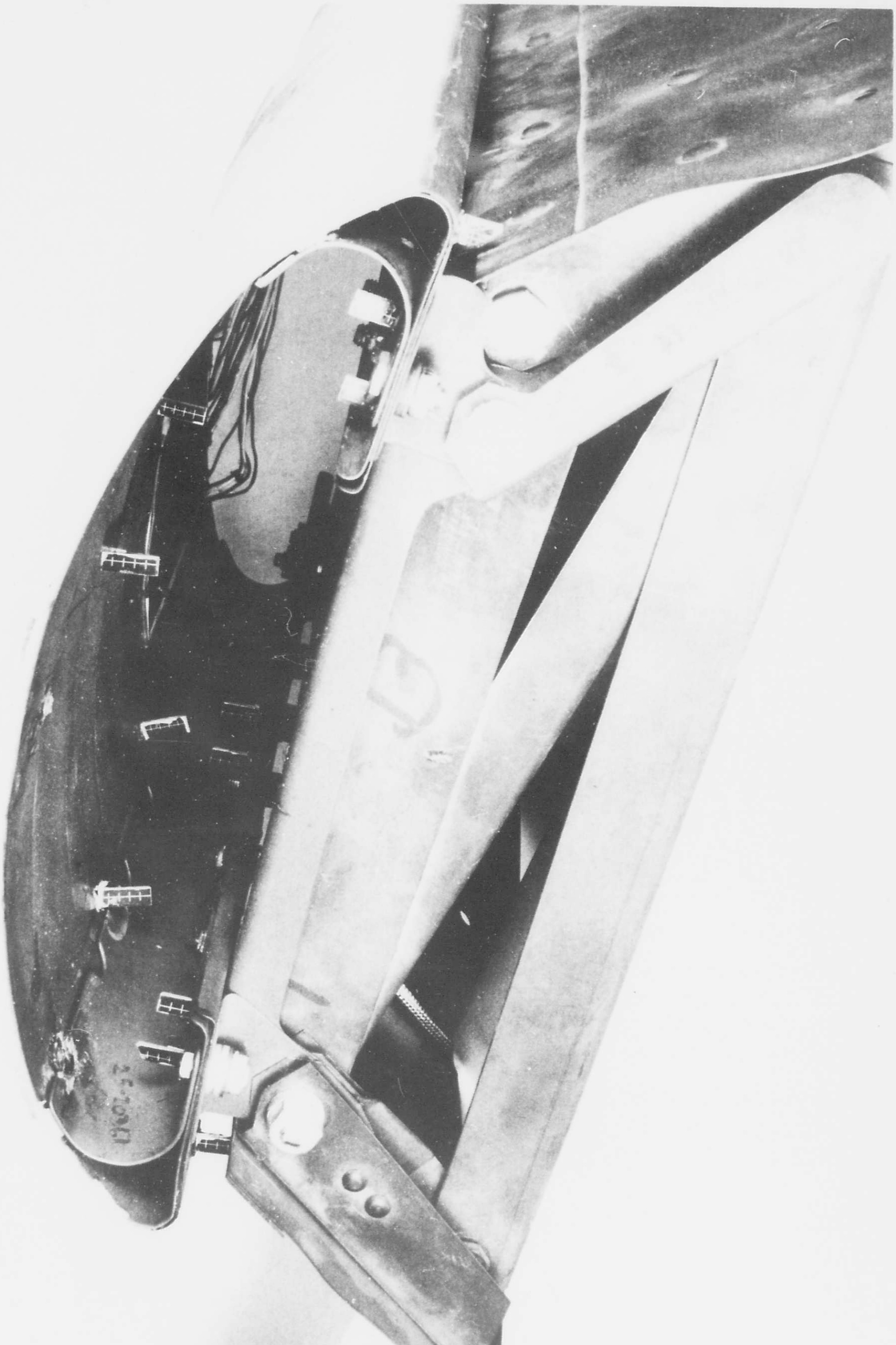

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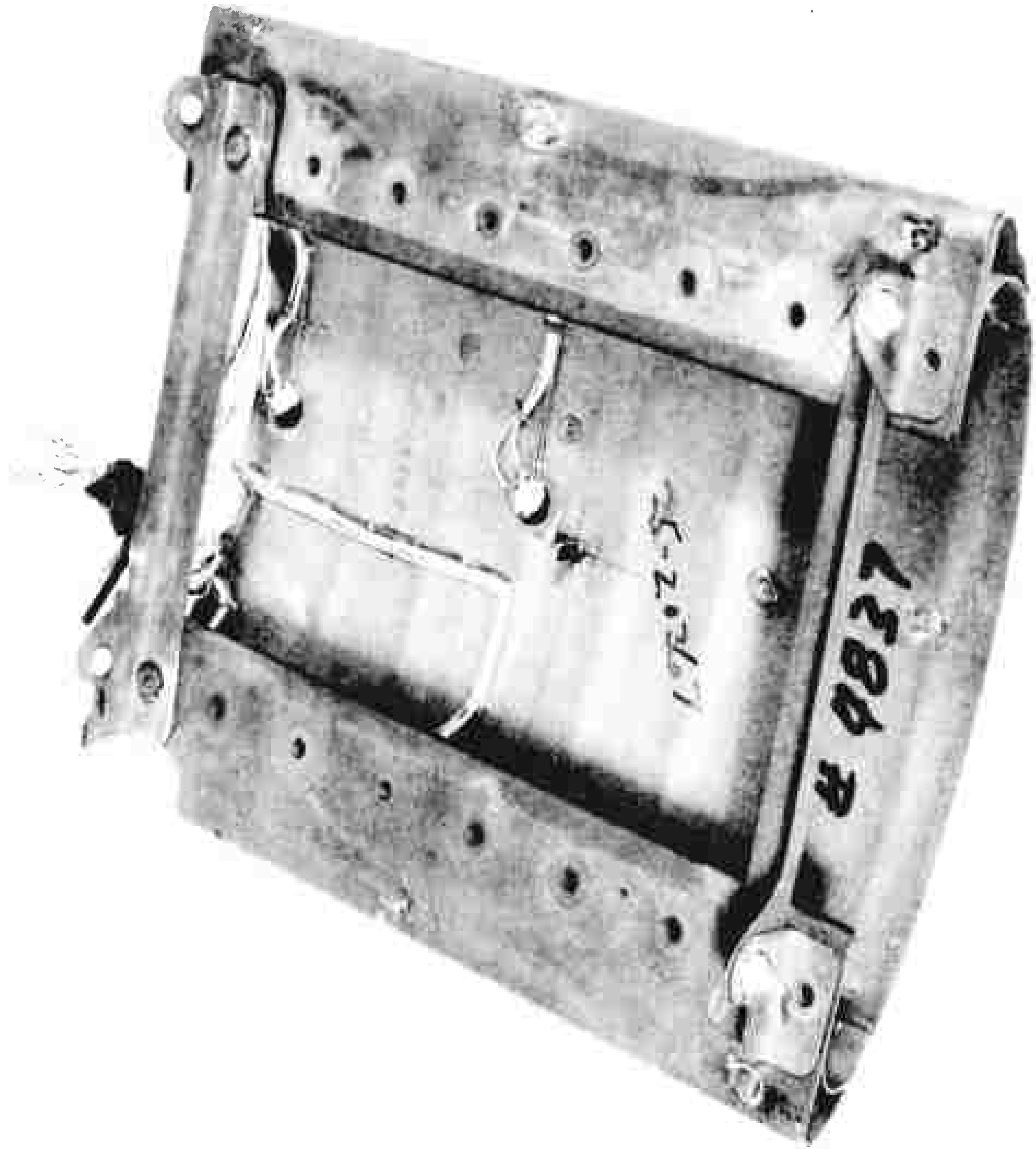

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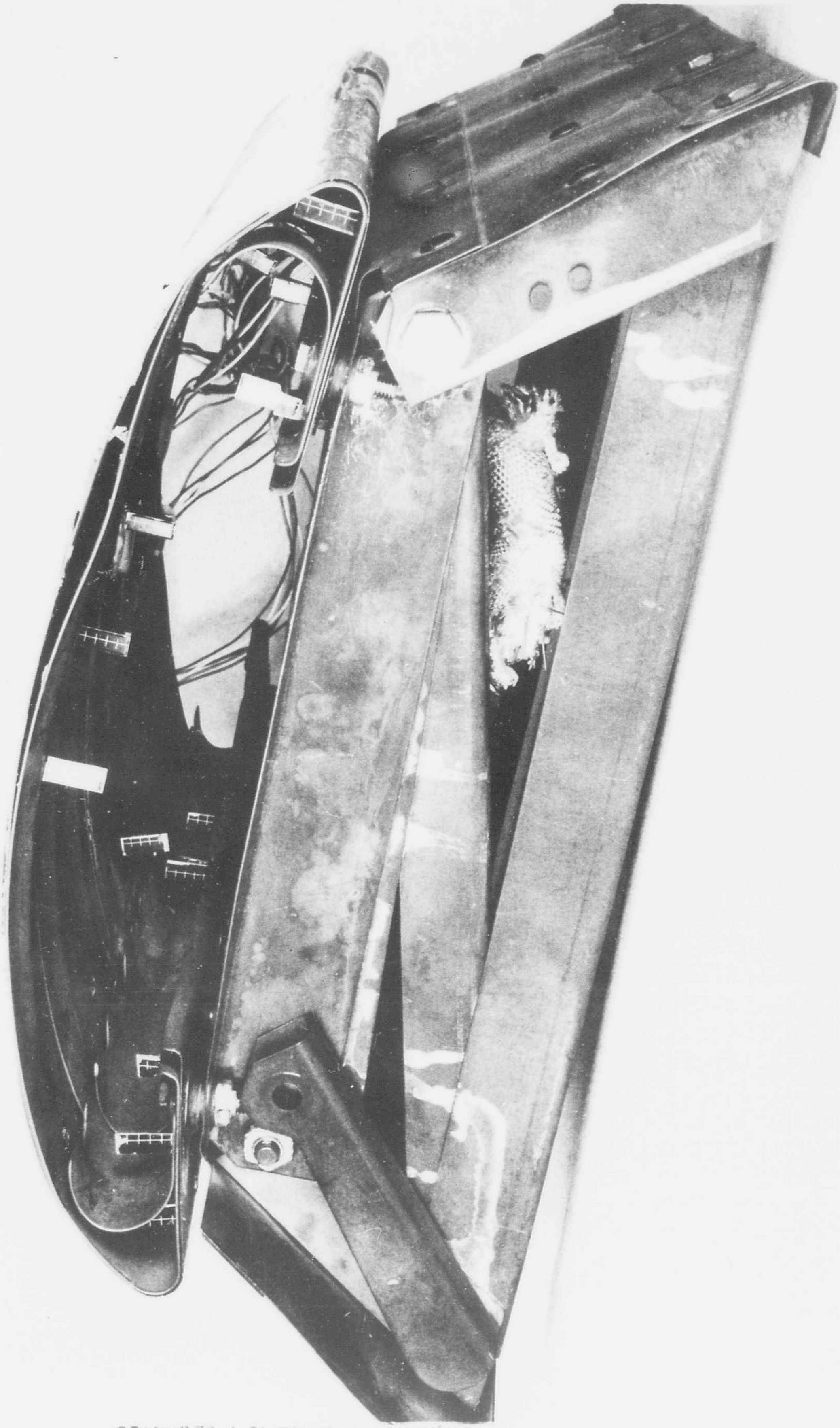
DS-I FAILED LEADING EDGE SPECIMEN 25-20367 1-30-62 2A100986

D8-I LEADING EDGE FAILURES 1-17-62 2A96279
#25-20378



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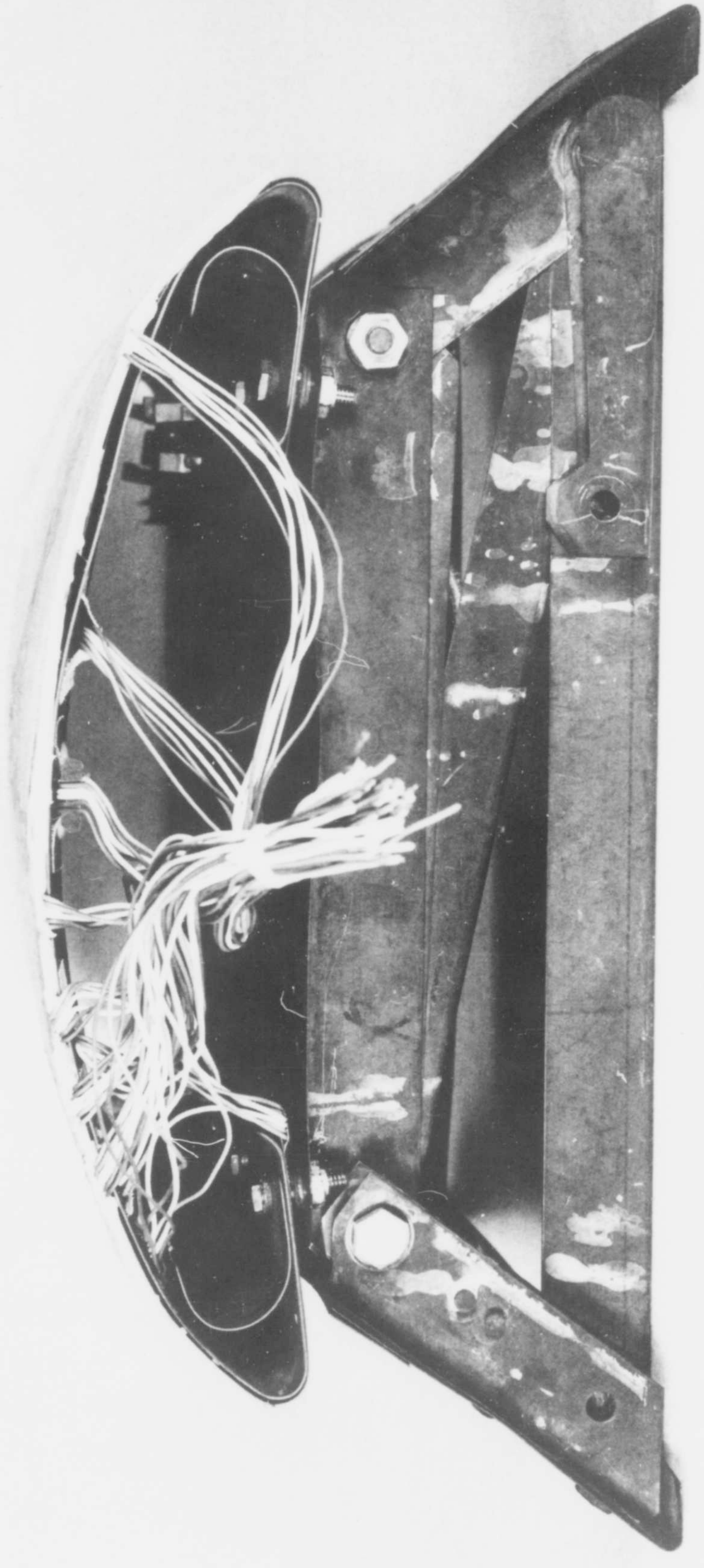

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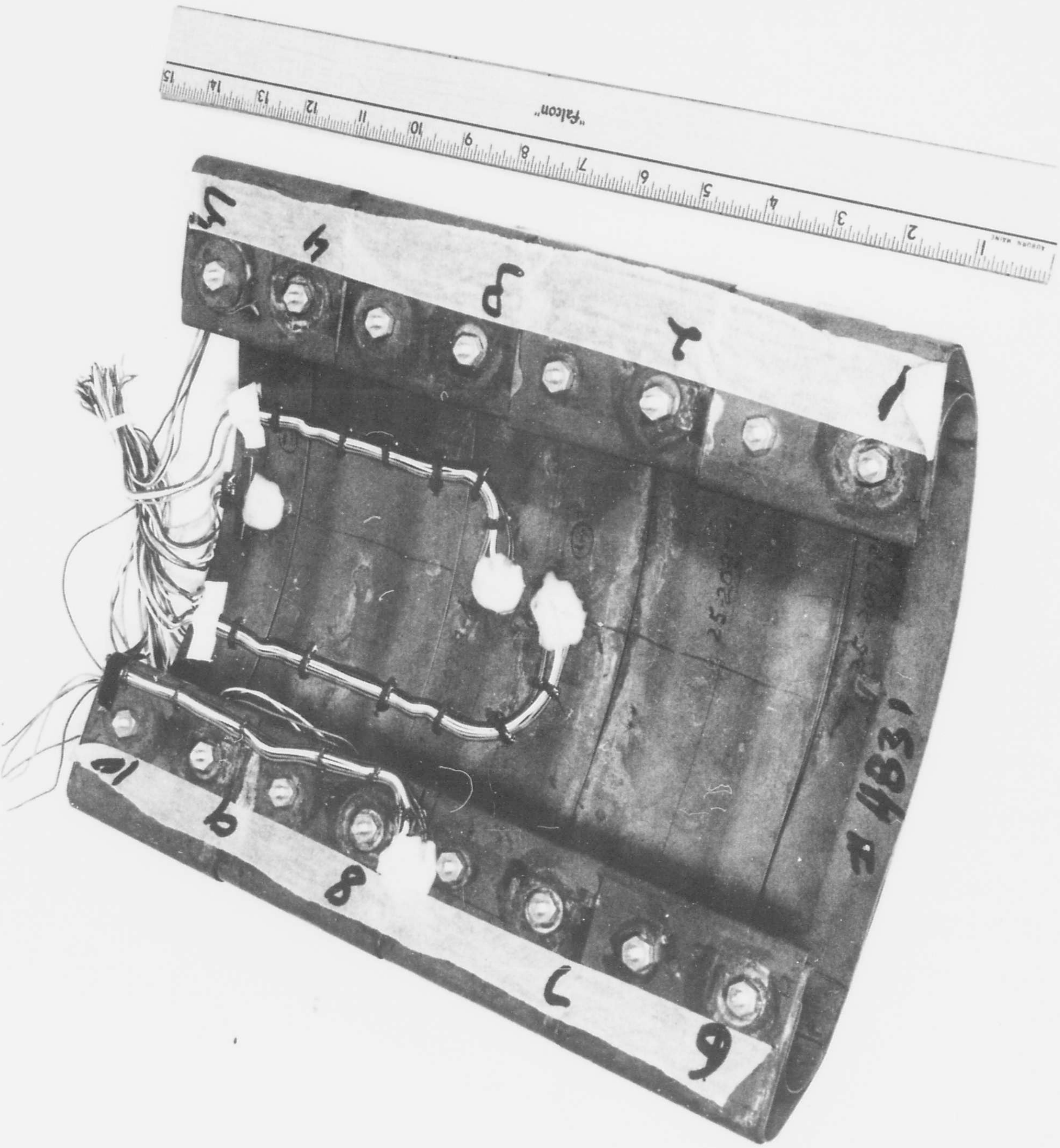

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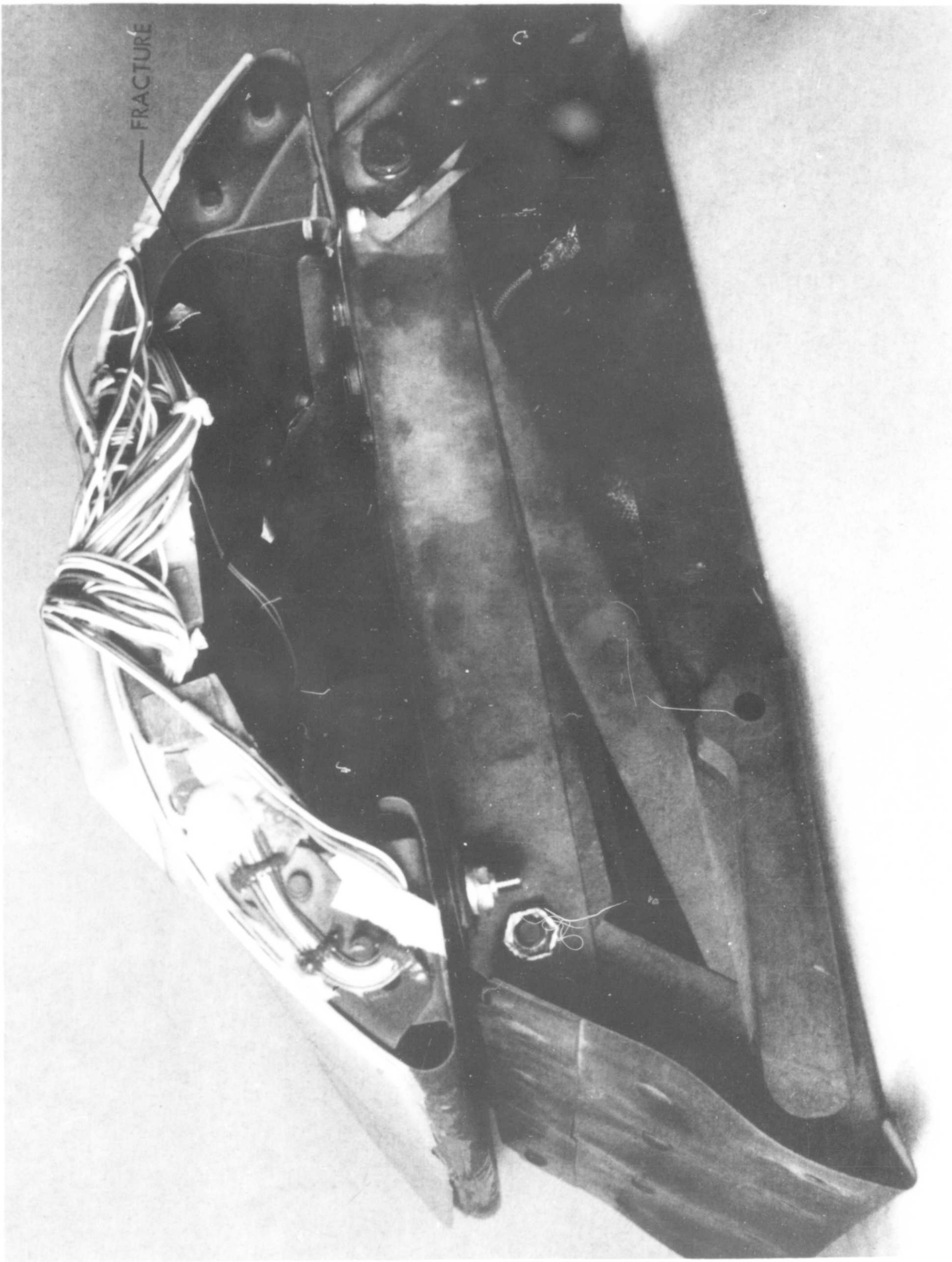
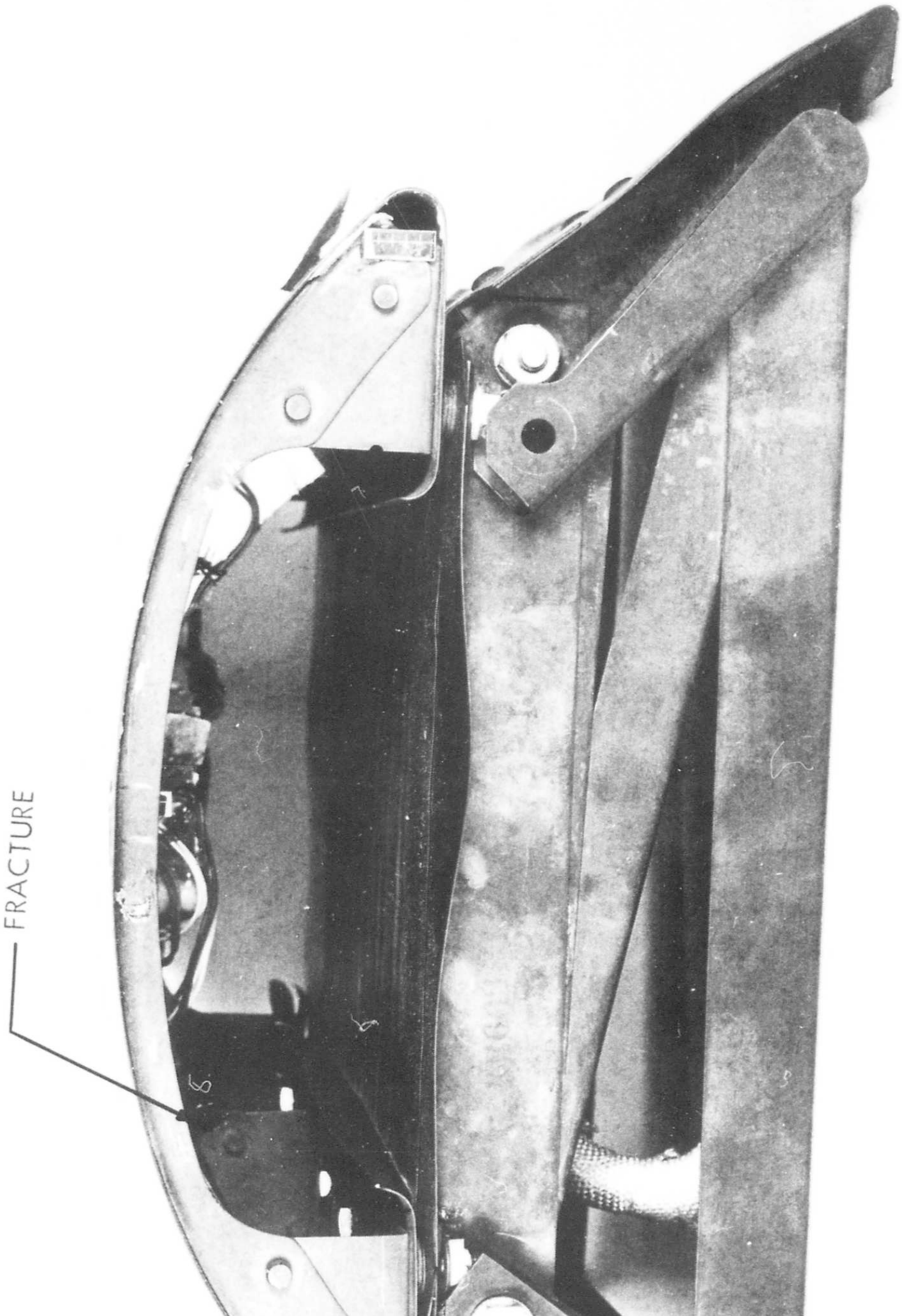


25-20376-1 SLO V-LOAD TESTED

1-17-62

#25-20376



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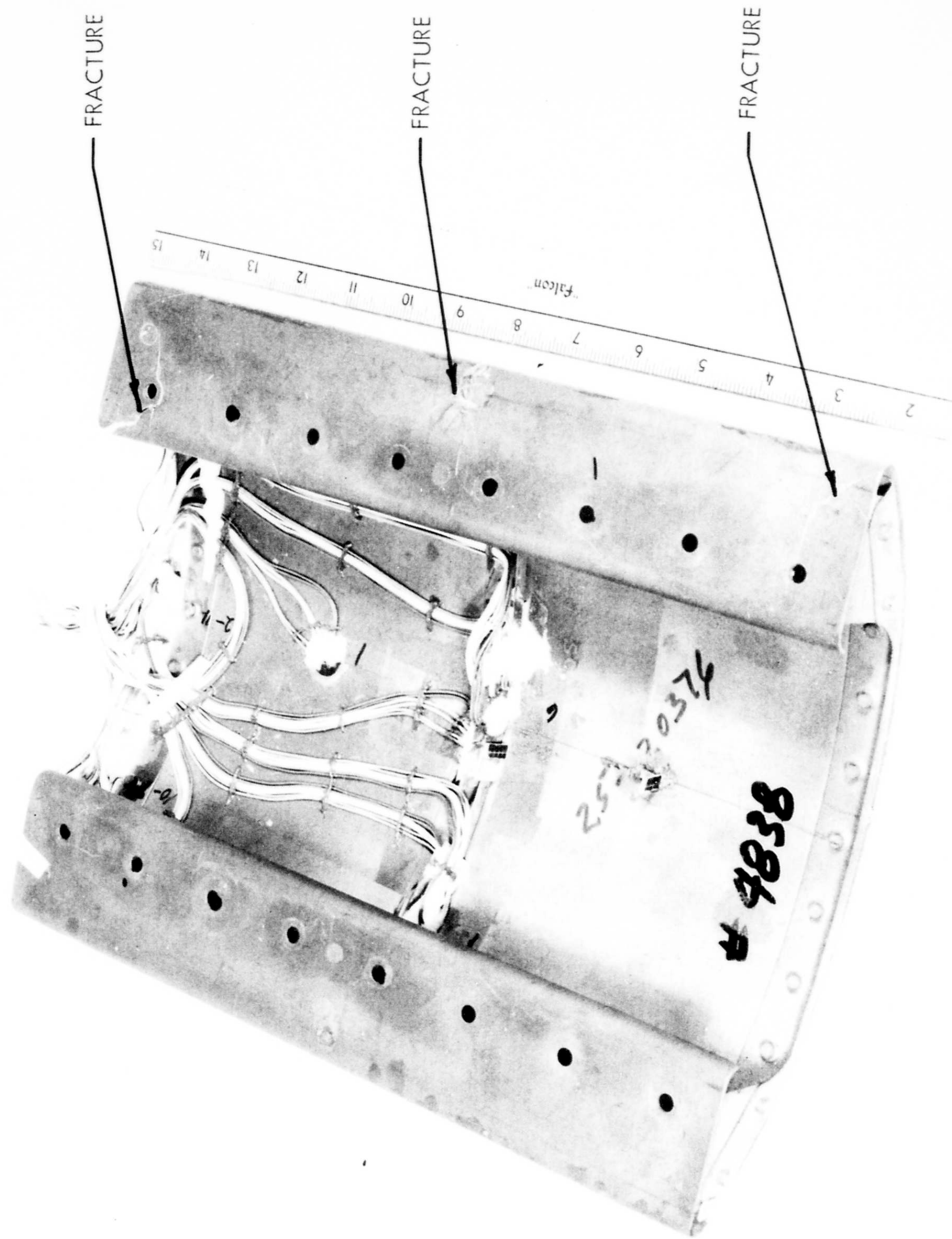

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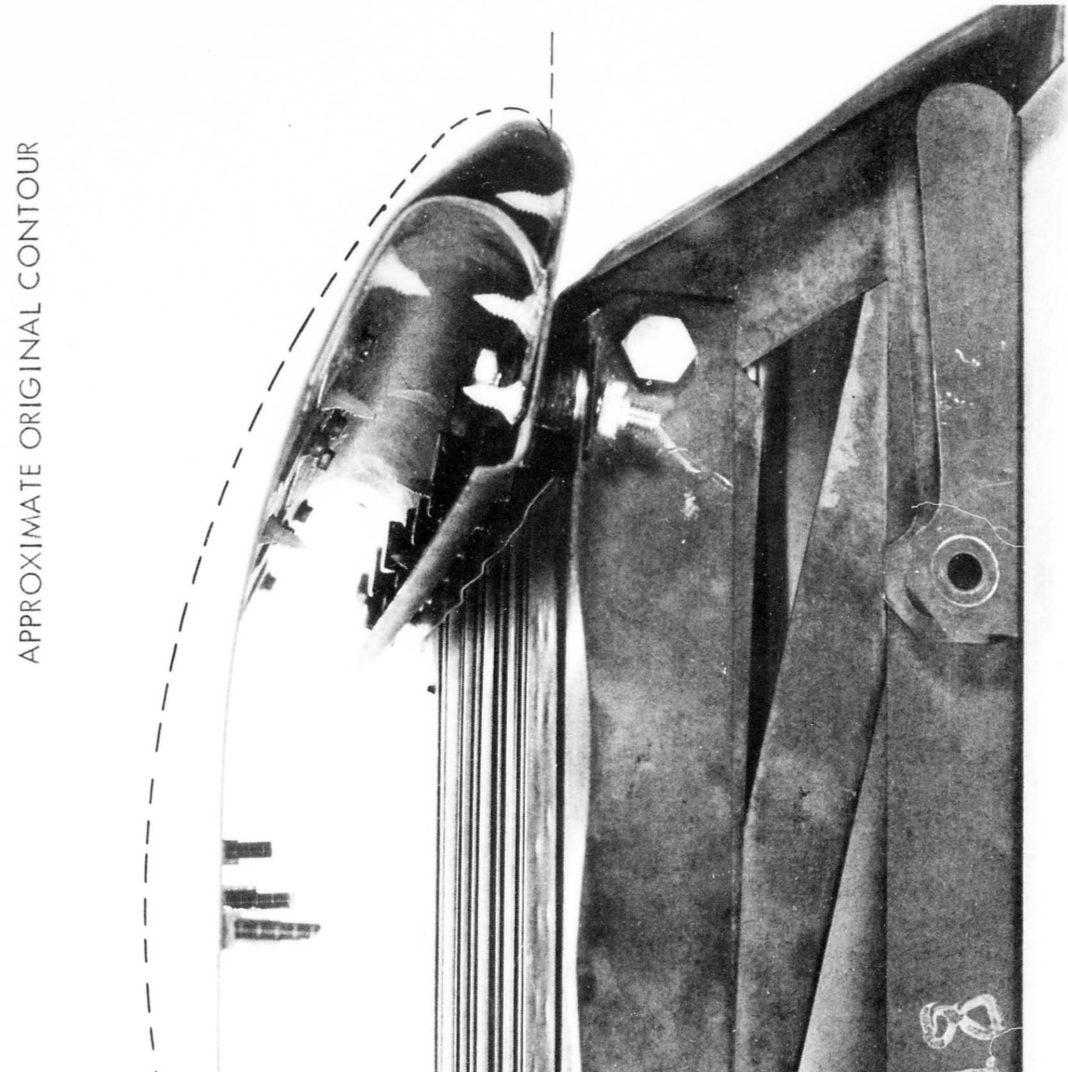
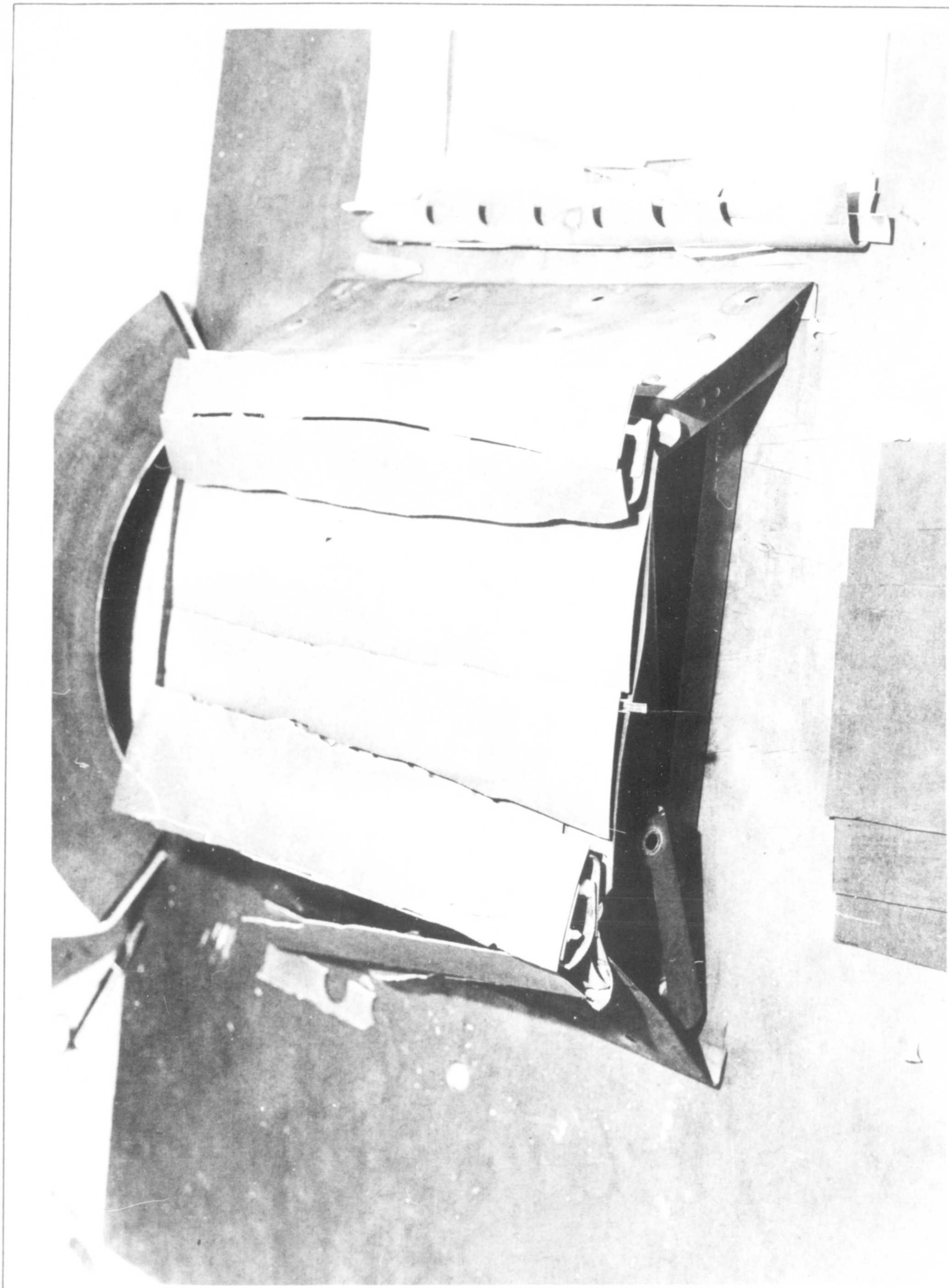


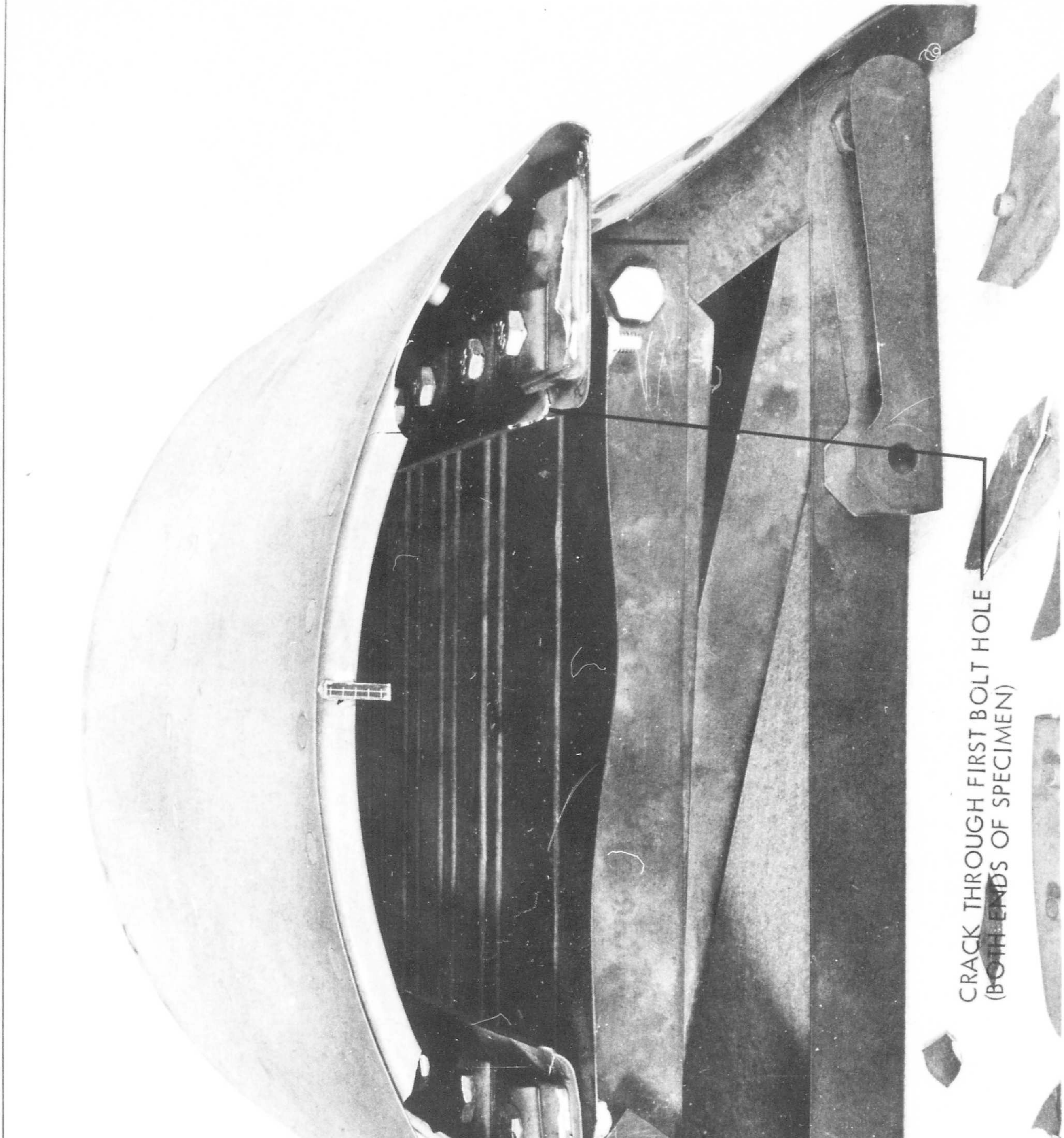
25-20341-1 SLOW-LOAD TESTED

DS-I LEADING EDGE FAILURES - END VIEW
3-9-62
2A102947

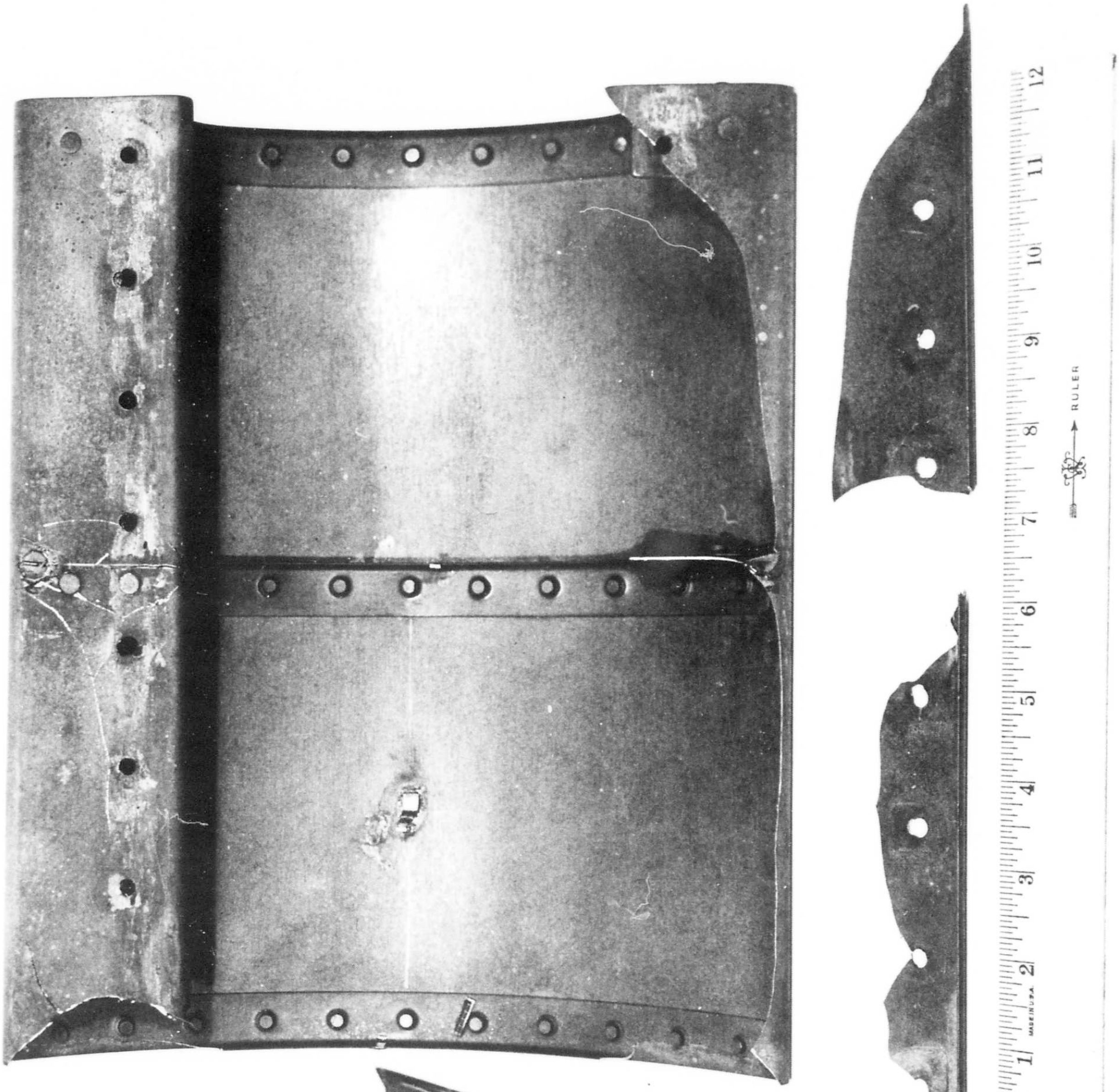


25-20341-2 RAPID-LOAD TESTED

3-6-62



25-20376-2 RAPID-LOAD TESTED



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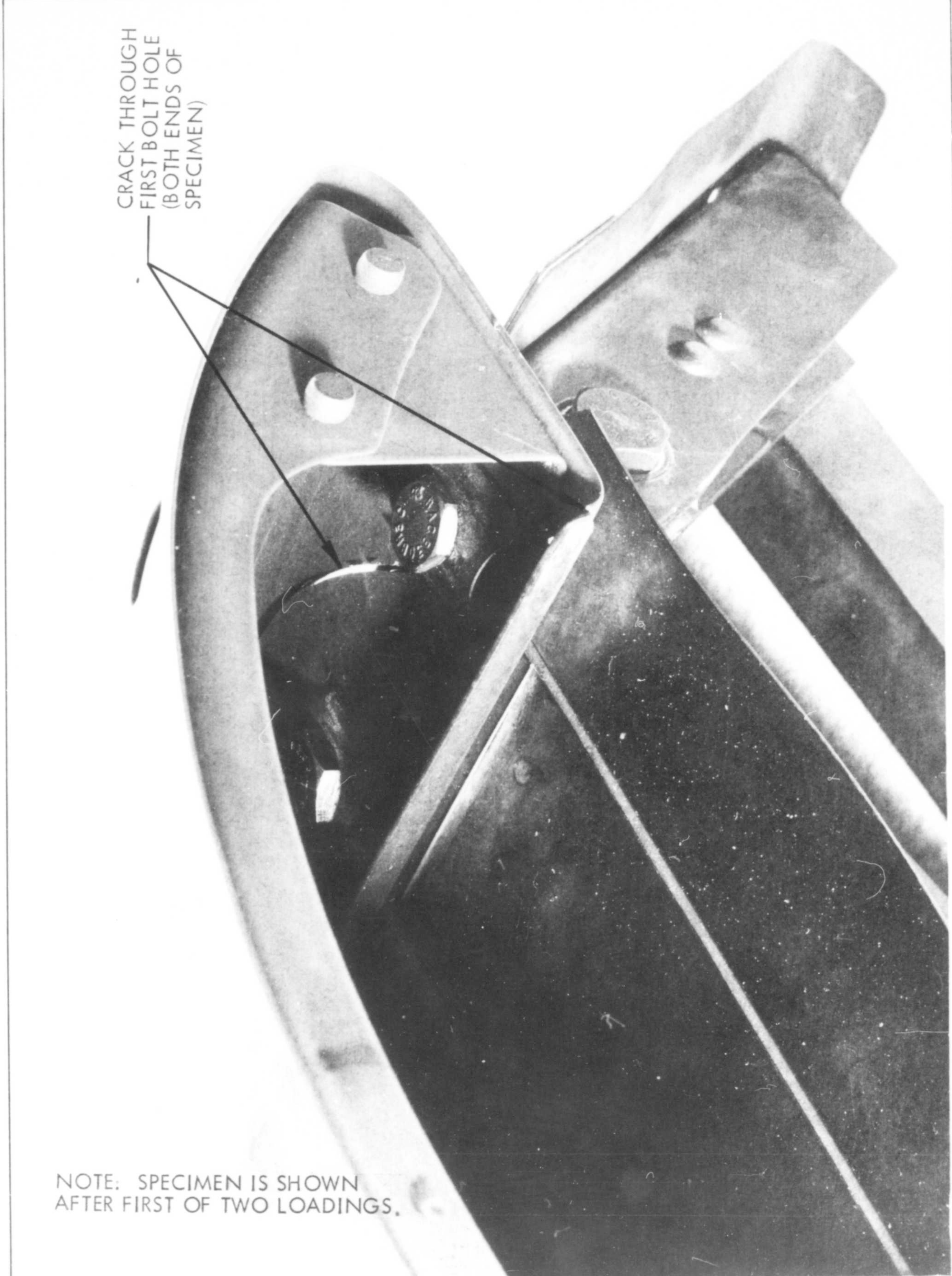
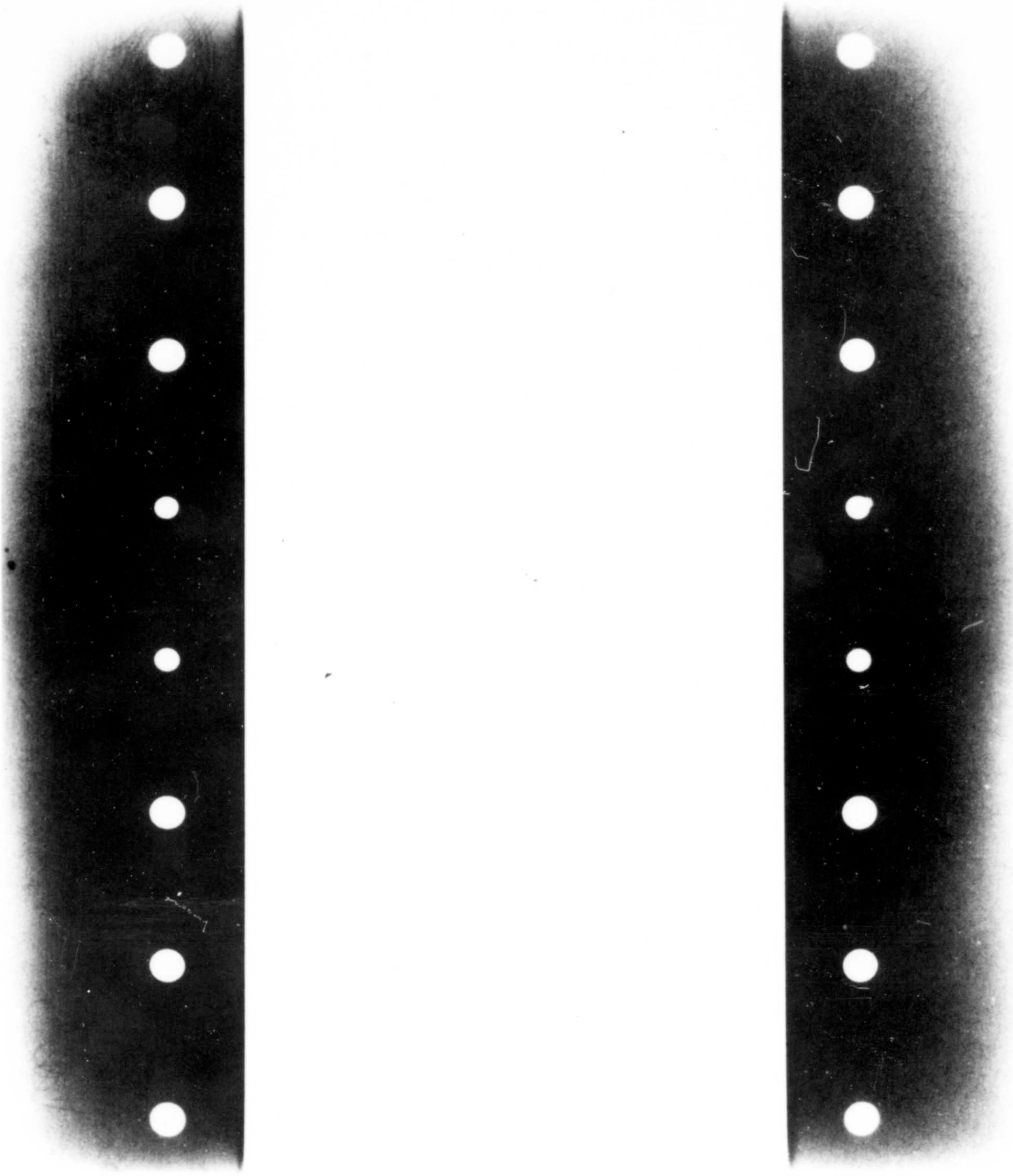
25-20376-2 RAPID-LOAD TESTED



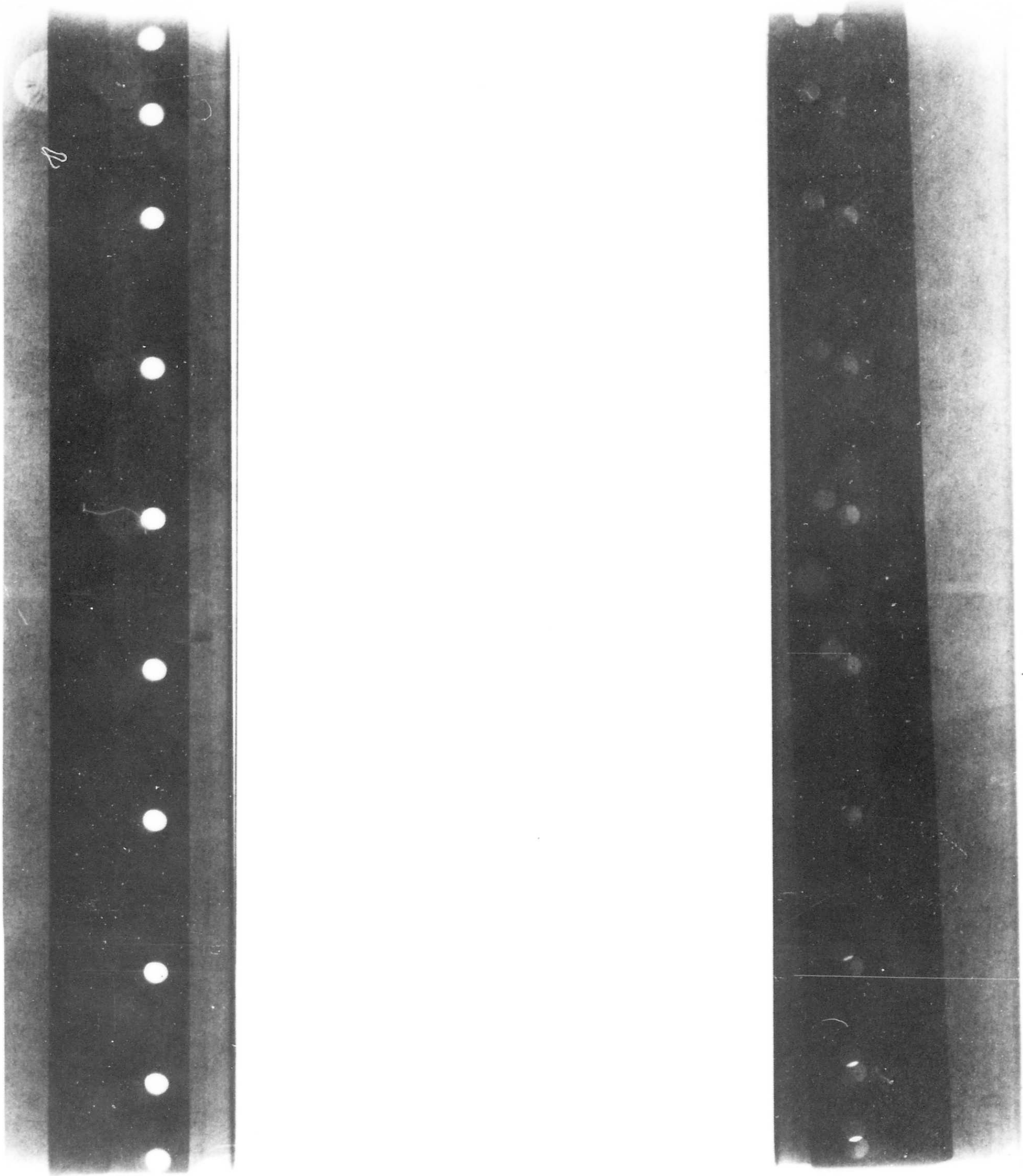
25-20376-2 RAPID-LOAD TESTED



CALC			REVISED	DATE	X-RAY OF LEADING EDGE SPECIMEN 25-20372 AFTER TEST DS-I LEADING EDGE LOAD TESTS	D2-80085
CHECK						
APPD						
APPD					BOEING AIRPLANE COMPANY Fig. 3-105	PAGE 3-123

U3 4036 3000 (WAS BAC 973D-R3) 2-7000

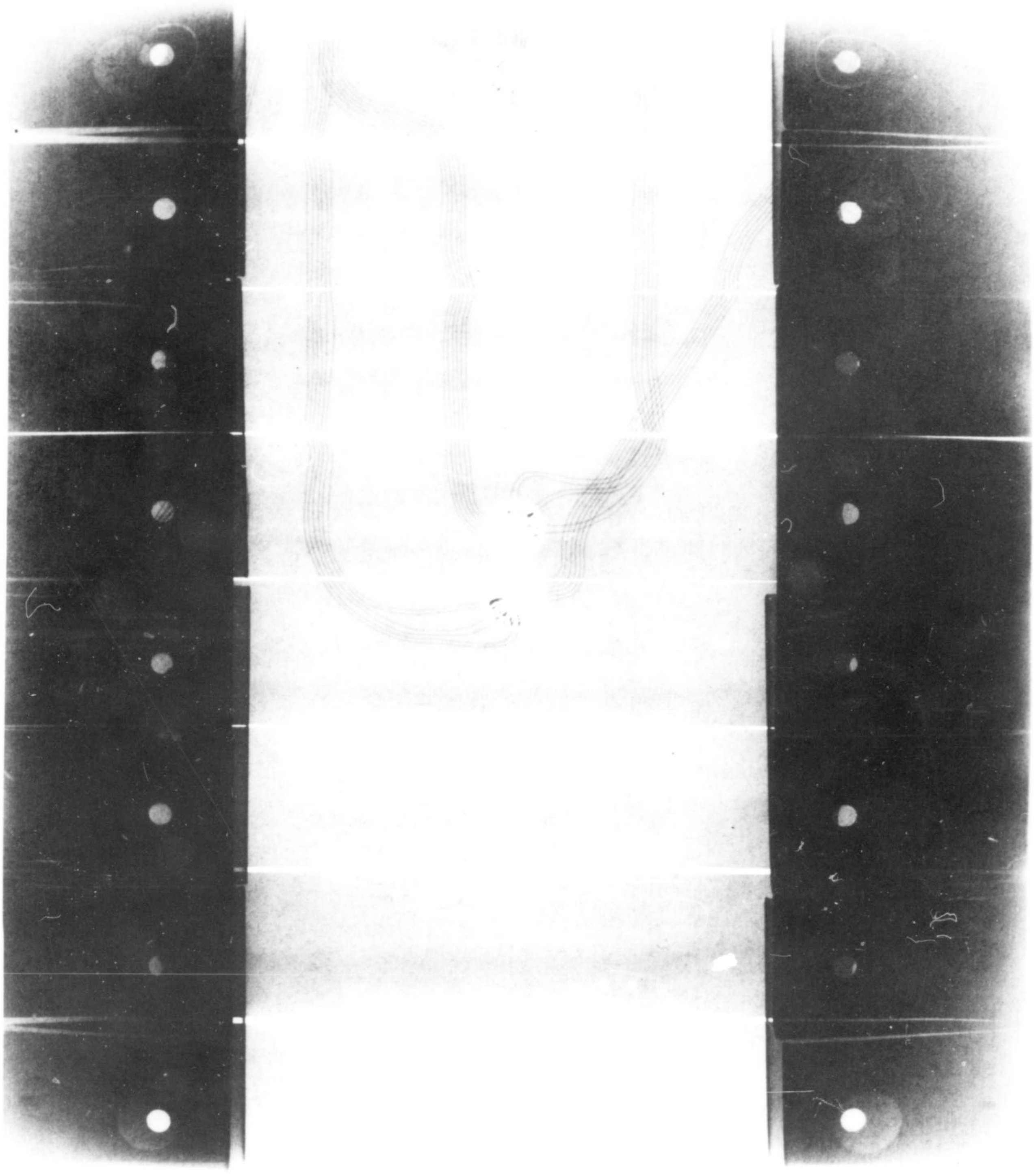
Volume I



CALC			REVISED	DATE	X-RAY OF LEADING EDGE SPECIMEN 25-20367 AFTER TEST DS-1 LEADING EDGE LOAD TESTS	D2-80085
CHECK						
APPD						
APPD					BOEING AIRPLANE COMPANY Fig. 3-106	PAGE 3-124

U3 4036 3000 (WAS BAC 973D-R3)

Volume I

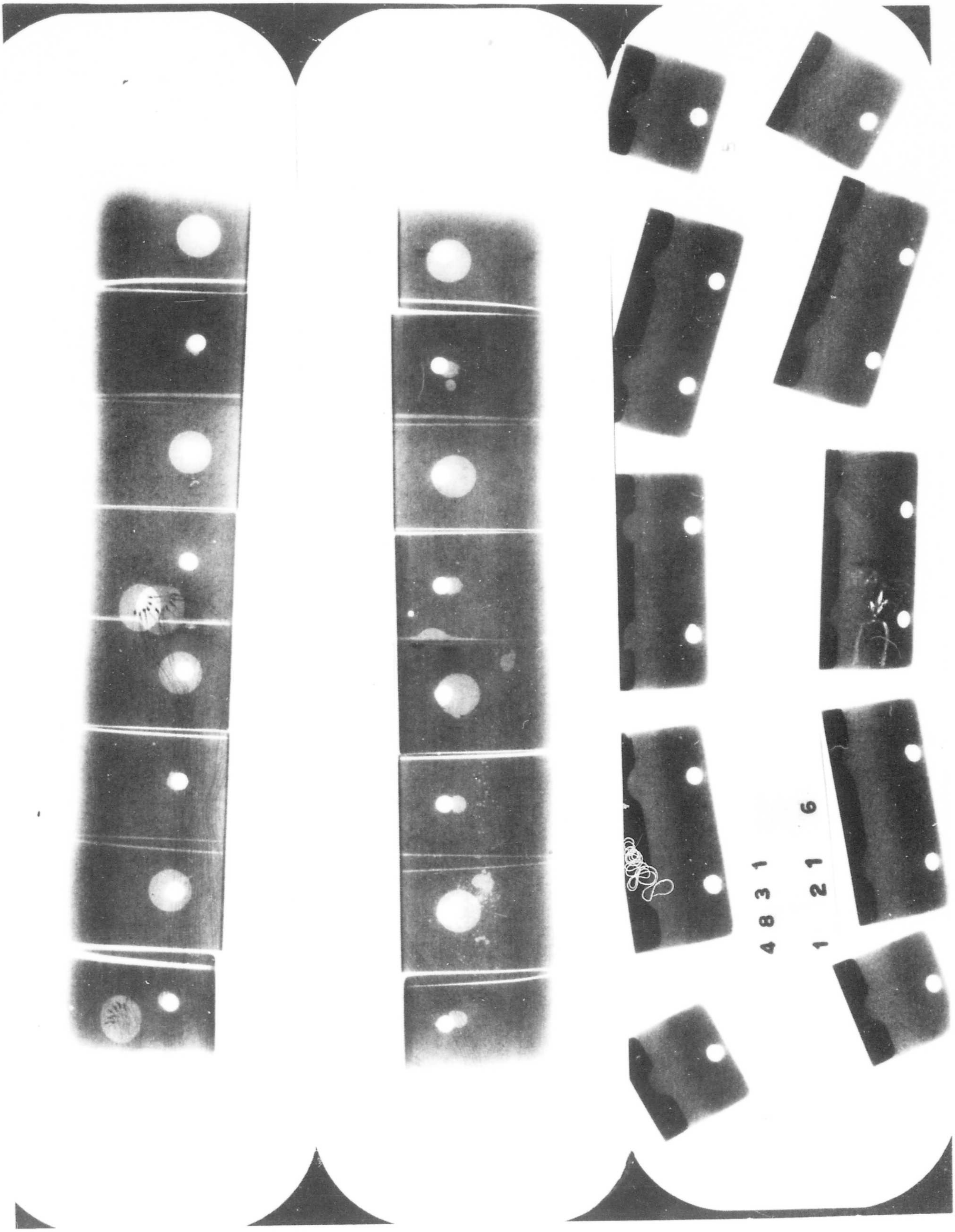


CALC			REVISED	DATE	X-RAY OF LEADING EDGE SPECIMEN 25-20378 AFTER TEST DS-I LEADING EDGE LOAD TESTS	D2-80085
CHECK						
APPD						
APPD					BOEING AIRPLANE COMPANY Fig. 3-107	PAGE 3-125

U3 4036 3000 (WAS BAC 973D-R3)

Volume I

2-7000



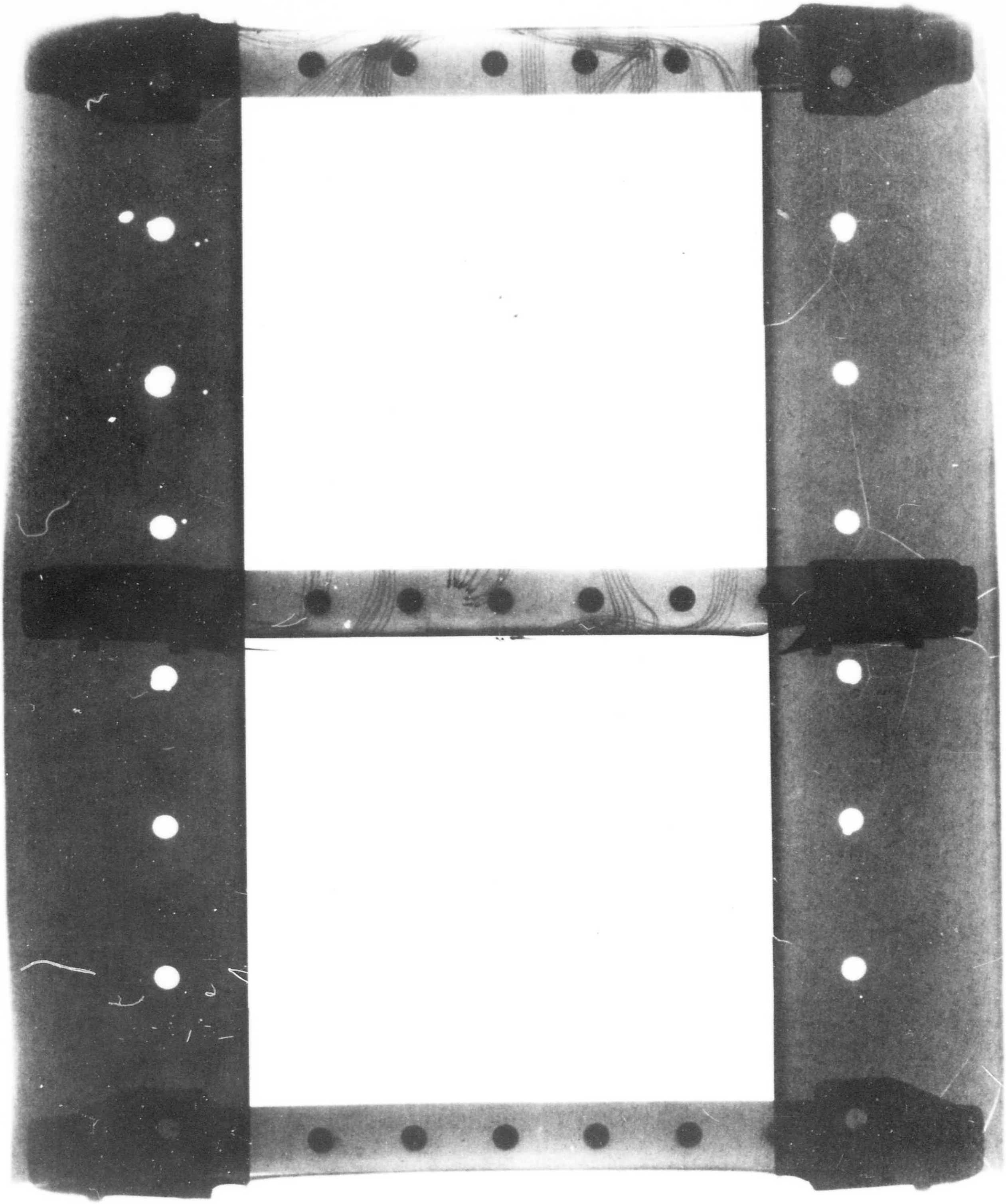
			REVISED	DATE	
CALC					X-RAY OF LEADING EDGE SPECIMEN 25-20378 AFTER TEST DS-I LEADING EDGE LOAD TESTS
CHECK					
APPD					D2-80085
APPD					BOEING AIRPLANE COMPANY

Fig. 3-108

U3 4036 3000 (WAS BAC 973D-R3)

2-7000

Volume I

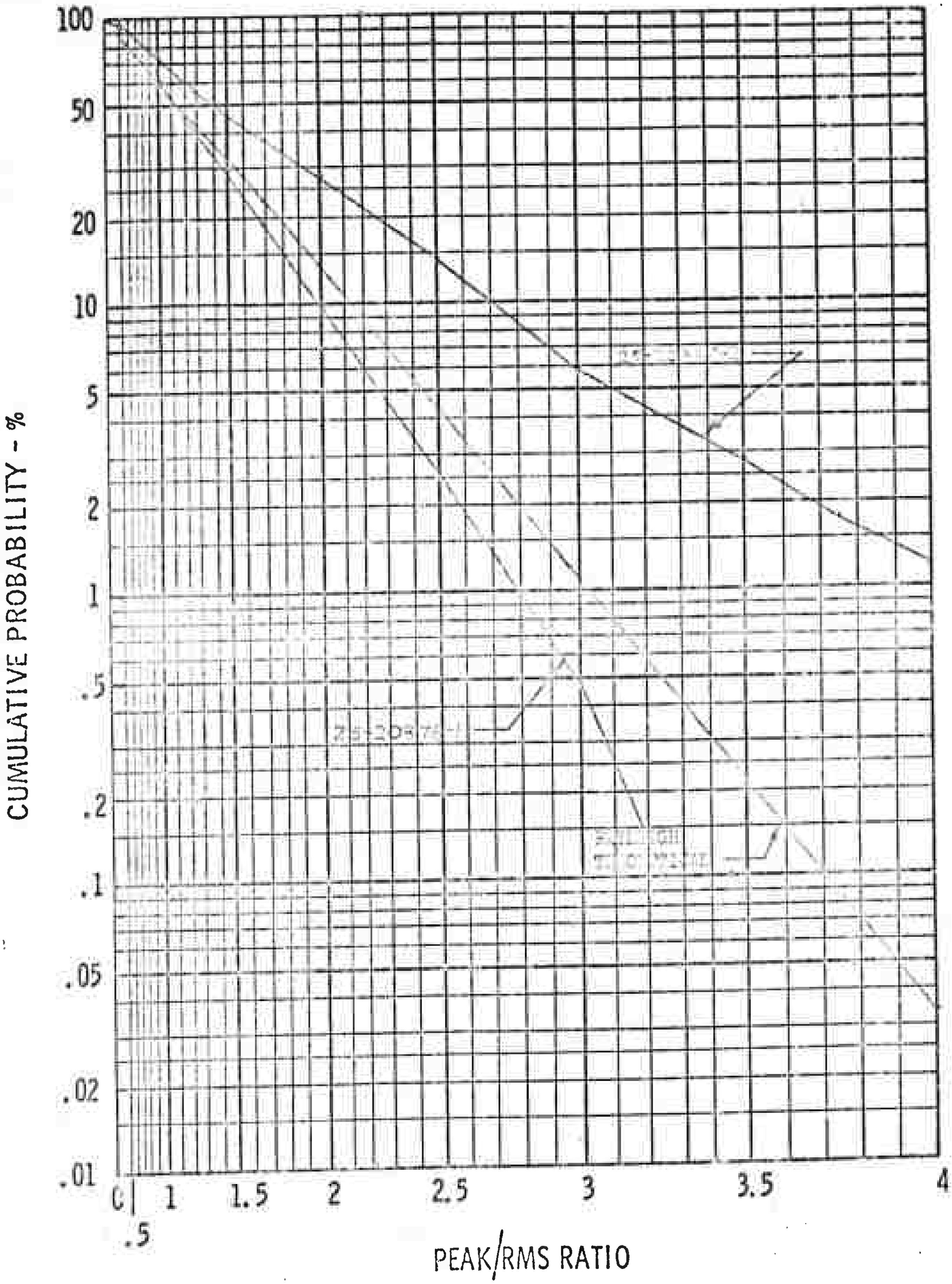


			REVISED	DATE		
CALC					X-RAY OF LEADING EDGE SPECIMEN 25-20376 AFTER TEST DS-1 LEADING EDGE LOAD TESTS	D2-80085
CHECK						
APPD						
APPD					BOEING AIRPLANE COMPANY	PAGE 3-127
					Fig. 3-109	

U3 4036 3000 (WAS BAC 973D-R3)

2-7000

Volume I



CALC	H. M. Wilson	6-5-63	REVISED	DATE	AMPLITUDE DISTRIBUTION LIMITS FOR ALL LEADING EDGE SPECIMENS TESTED	D2-80085
CHECK						Sect. 3
APPD					BOEING AIRPLANE COMPANY	PAGE 3-128
APPD						Fig. 3-110

2-7000

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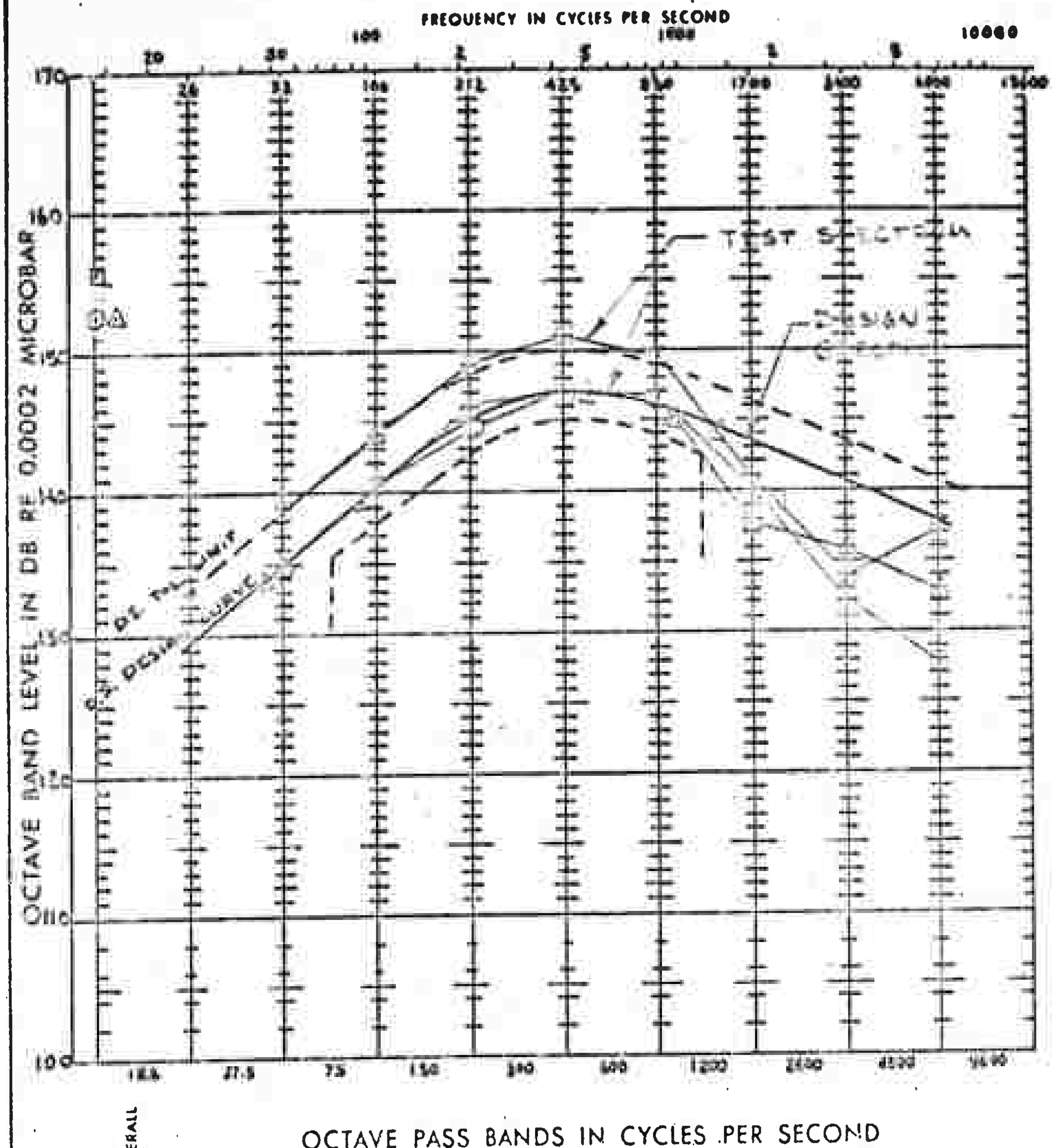
130 2-5353-7-1 9-3-63

E.WA



MIC. #1
25-20372-1
O PHASE A
Δ PHASE B
□ PHASE C

EQUILIZER SETTINGS	
20 - 75	33
75 - 150	19.5
150 - 300	17.0
300 - 600	10.0
600 - 1200	3.0
1200 - 2400	-1.0
2400 - 4800	∞
4800 - 9600	∞
O 3.6	40
Δ 3.6	40
□ 4.0 AMPS	55 PSI

CALC DH. for A.S. DATE 6/5/63

2-5353-7-7

9-3-63

BOEING
SONIC LAB.

NO. D2-20085

PAGE 3-129
Fig.3-111

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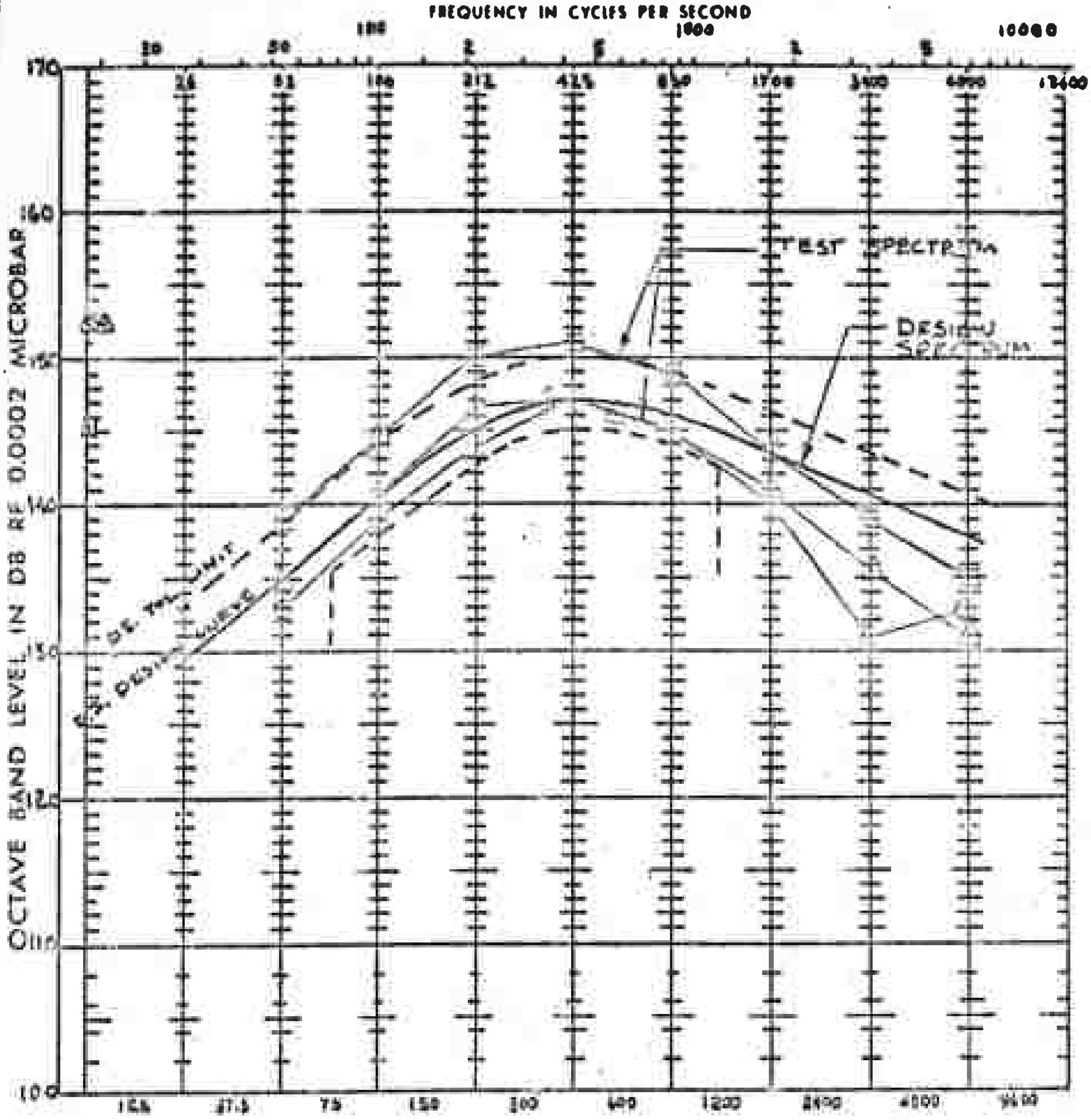
E.WA



EQUILIZER SETTINGS	○	△ □
20 - 75	33	33
75 - 150	19.5	24.0
150 - 300	17	20
300 - 600	10	11
600 - 1200	3.5	3.8
1200 - 2400	-1.0	-1.0
2400-4800	∞	∞
4800-9600	∞	∞

○ 3.3	36	
△ 4.0	36	
□ 4.2 AMPS	50	PSI

MIC #1
25-20372-2
○ PHASE A
△ PHASE B
□ PHASE C

2-5353-7-7
9-3-63

CALC DH for AB DATE 6/7/63
BOEING NO. D2-80085
SONIC LAB. PAGE Fig. 3-112
3-130.
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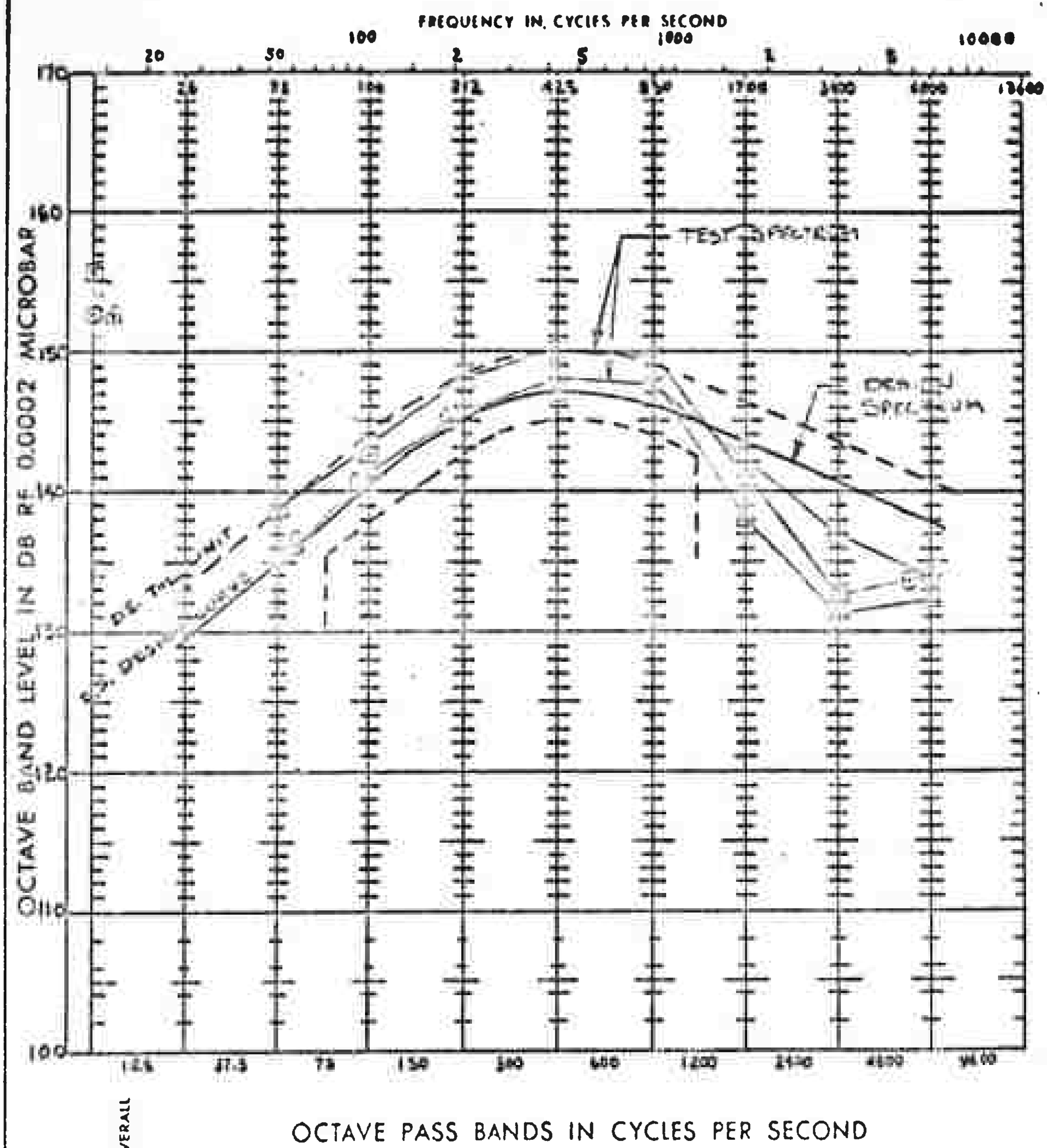
E.WA



EQUILIZER SETTINGS	○	△□
20 - 75	18.0	
75 - 150	15.5	
150 - 300	16.5	
300 - 600	10.0	
600 - 1200	3.5	
1200 - 2400	-1.0	
2400-4800	∞	
4800-9600	∞	
○ 3.4	52	
△ —	—	
□ — AMPS	—	PSI

MIC #1

25-20367-1

○ PHASE A

△ PHASE B

□ PHASE C

CALC DH for AB DATE 6/7/63

2-5353-7-7

9-3-63

BOEING NO. D2-80085

SONIC LAB. PAGE 3-131 Fig. 3-113

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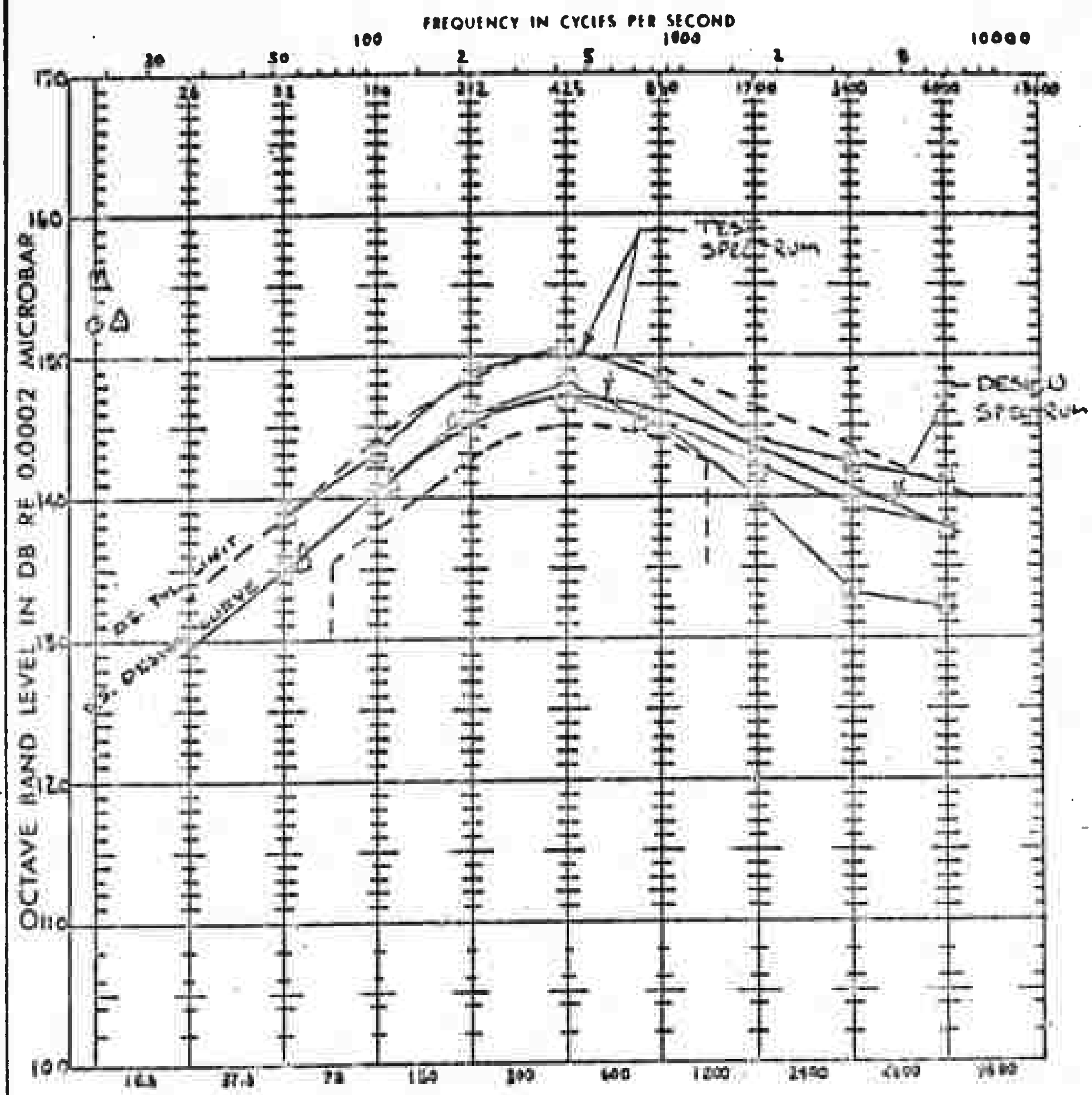
E.WA



EQUILIZER SETTINGS	O	△ □
20 - 75	23	29
75 - 150	15.5	22
150 - 300	16.5	20
300 - 600	10	10
600 - 1200	7	-1
1200 - 2400	-1	-1
2400 - 4800	∞	∞
4800 - 9600	∞	∞

O 3.2	40	
△ 4.0	50	
□ 4.0 AMPS	50	PSI

MIC #1
25-20367-2
O PHASE A
△ PHASE B
□ PHASE C

2-5353-7-7

9-3-63

CALC DH for AB DATE 6/7/63

BOEING NO. D2-80085

SONIC LAB. PAGE Fig. 3-114

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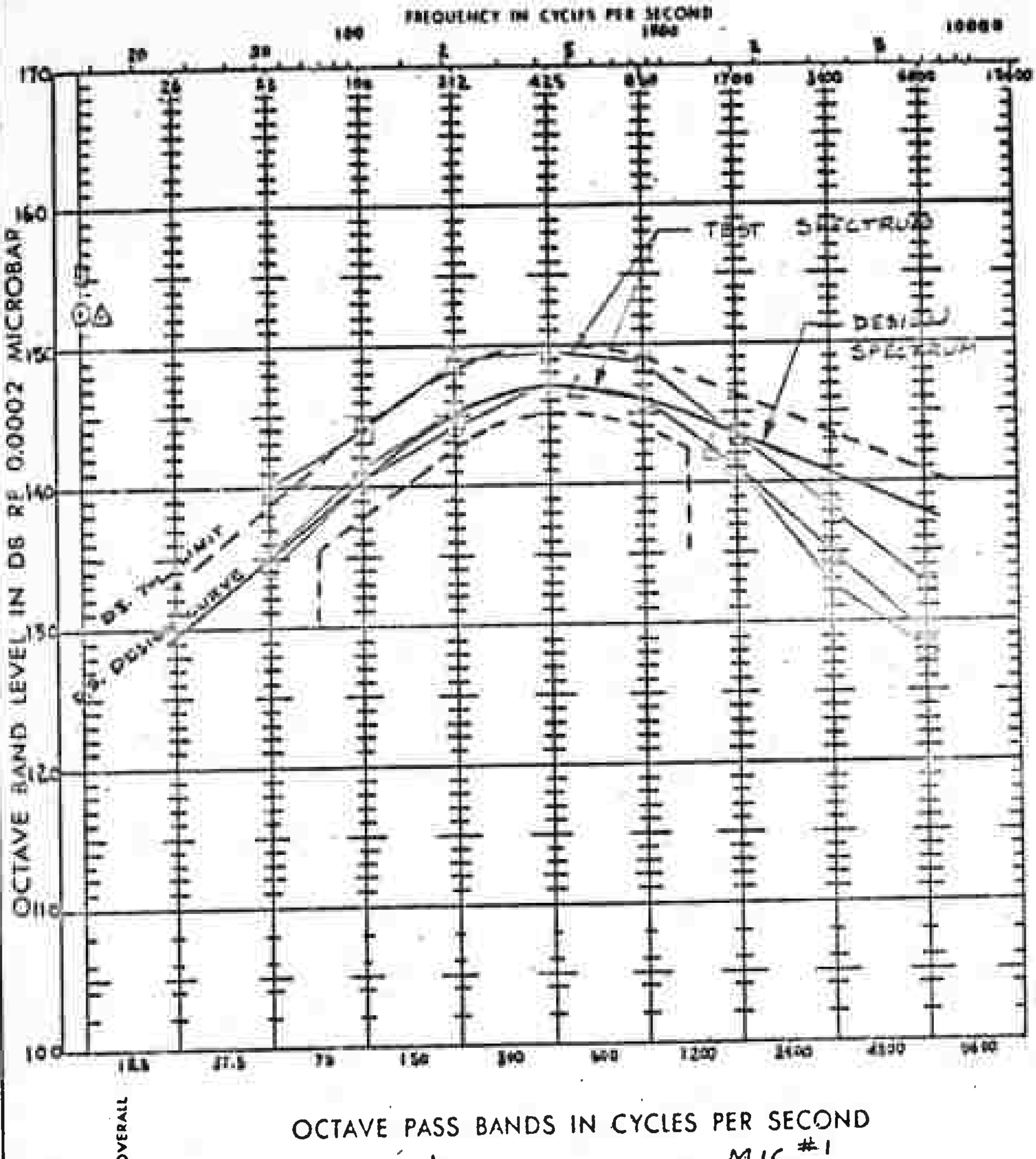
E.WA



MIC #1

25-20378-1

○ PHASE A

△ PHASE B

□ PHASE C

EQUILIZER SETTINGS	
20 - 75	28.2
75 - 150	19.5
150 - 300	17.0
300 - 600	10.1
600 - 1200	2.8
1200 - 2400	-1.0
2400 - 4800	∞
4800 - 9600	∞
○ 3.5	40
△ 3.5	40
□ 5.0 AMPS	50 PSI

2-5353-7-7

9-3-63

CALC DH for AB. DATE 6/5/63

BOEING NO. D2-80085

SONIC LAB. PAGE

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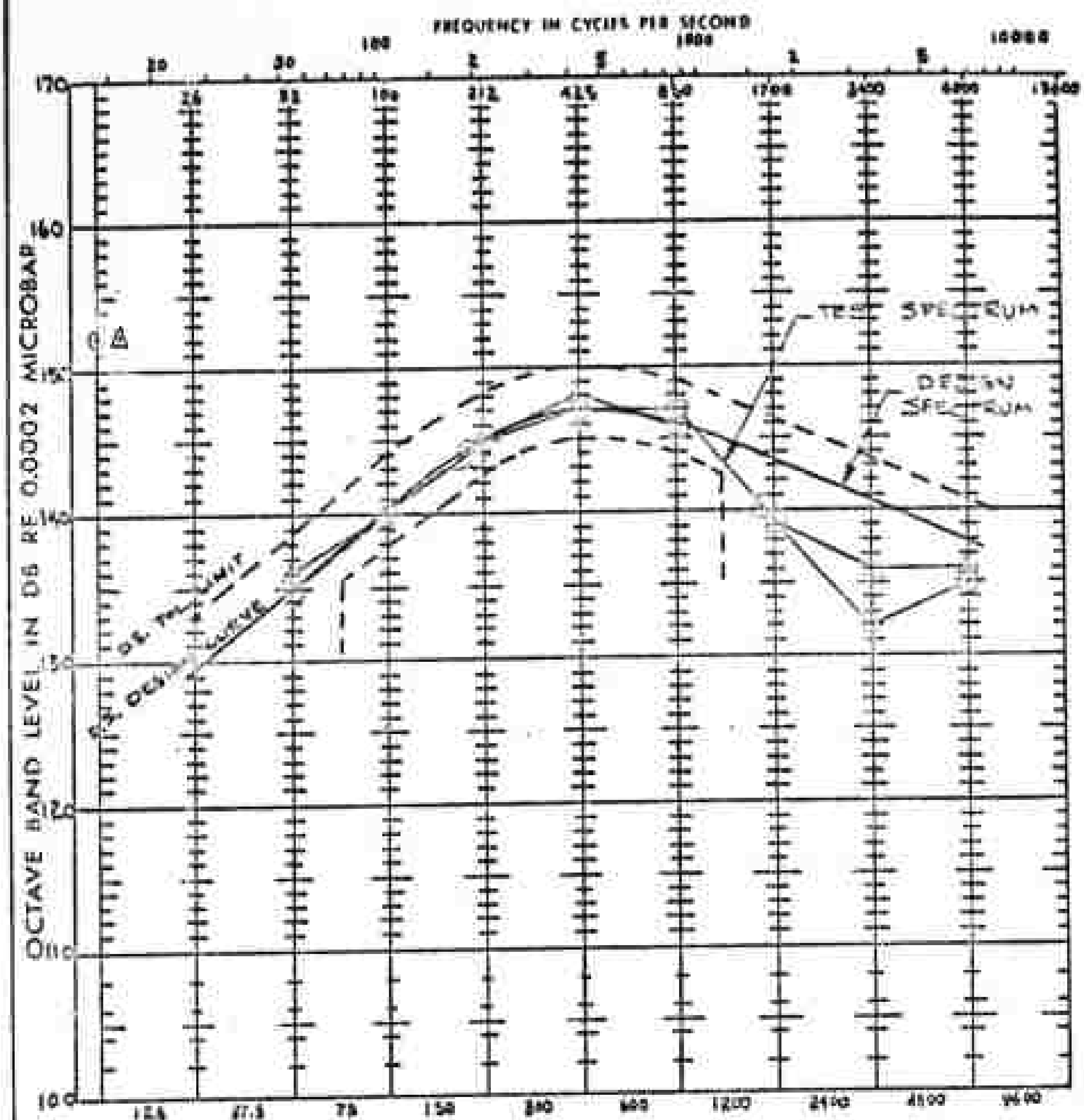
E.WA



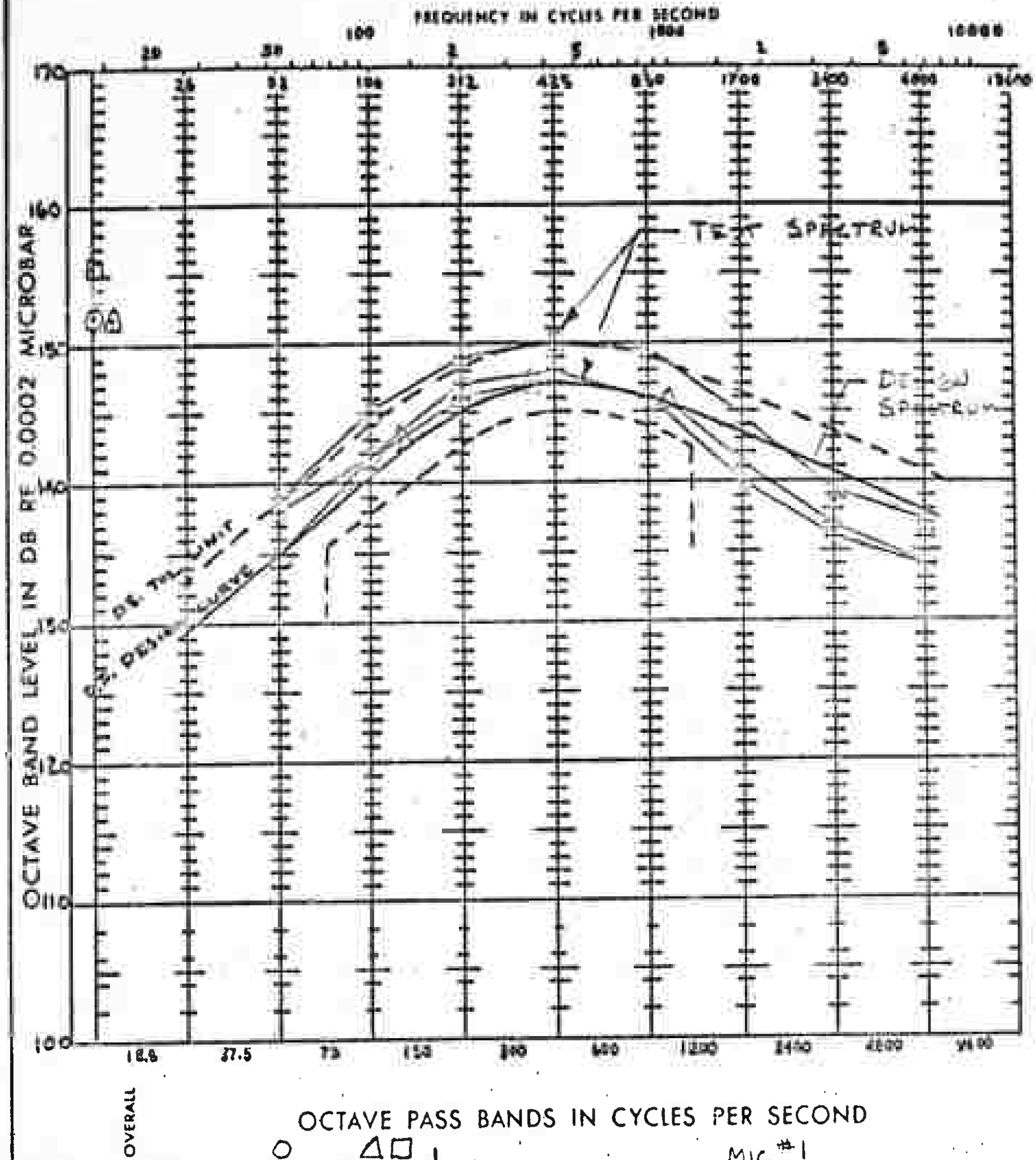
EQUILIZER SETTINGS	O	Δ
20 - 75	23	23.5
75 - 150	15.5	15.3
150 - 300	13	16.0
300 - 600	10	10.0
600 - 1200	3.5	4.5
1200 - 2400	-1	-1
2400 - 4800	∞	∞
4800 - 9600	∞	∞
O 2.5	60	
Δ 3.1 AMPS	36 PSI	

MIC #1
25-20378-2
O PHASE A
Δ PHASE B

2-5353-7-7
9-3-63

CALC DH for AB DATE 6/7/63
BOEING SONIC LAB.
NO. D2-80085
PAGE 3-134 Fig. 3-116
Volume I Sect. 3

EWA



Mic #1

25-20341-1

O PHASE A

Δ PHASE B

□ PHASE C

EQUILIZER SETTINGS	O	Δ□
20- 75	24.7	23.0
75- 150	15.5	15.5
150- 300	13.0	16.5
300- 600	10.3	12.5
600-1200	2.7	7.0
1200-2400	-0.8	-1.0
2400-4800	∞	∞
4800-9600	∞	∞
O 3.5	35	
Δ 3.4	52	
□ 4.2 AMPS	52	PSI

PER BANK OF 2 TRANSDUCERS (2 BANKS)

CALC DH for AB DATE 6/7/63

2-5353-7-7

9-3-63

BOEING SONIC LAB.

NO. D2-00085

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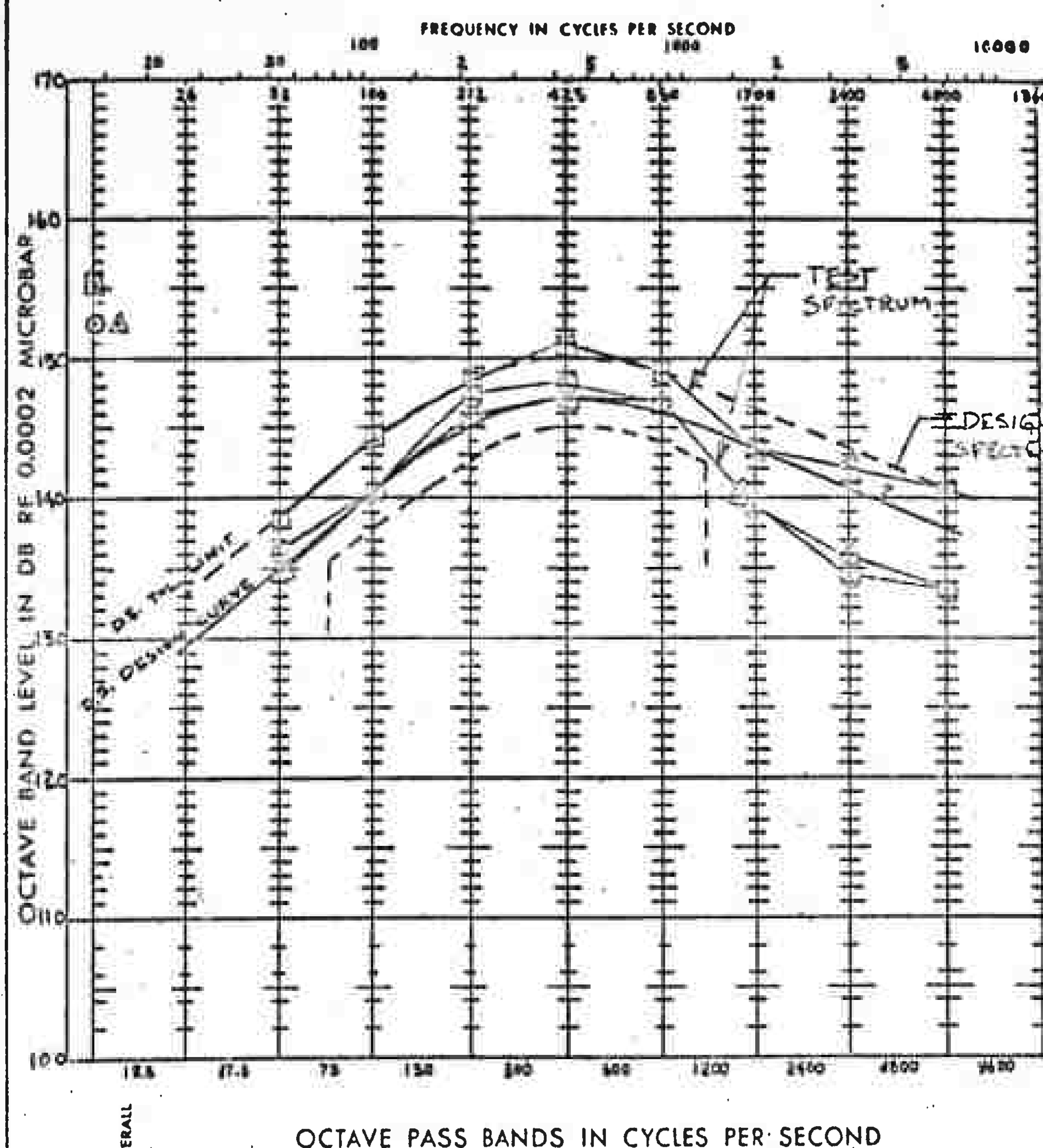
Volume I

E.WA



EQUILIZER SETTINGS	O	Δ	□
20 - 75	19	24	33
75 - 150	13	16	20.2
150 - 300	13	13	23.5
300 - 600	10	10	10.0
600 - 1200	3	3	-3
1200 - 2400	-1	-1	.7
2400-4800	∞	∞	∞
4800-9600	∞	∞	∞
O 2.2		50	
Δ 3.2		50	
□ AMPS			PSI

MIC #1
25-20341-2
O PHASE A
Δ PHASE B
□ PHASE C

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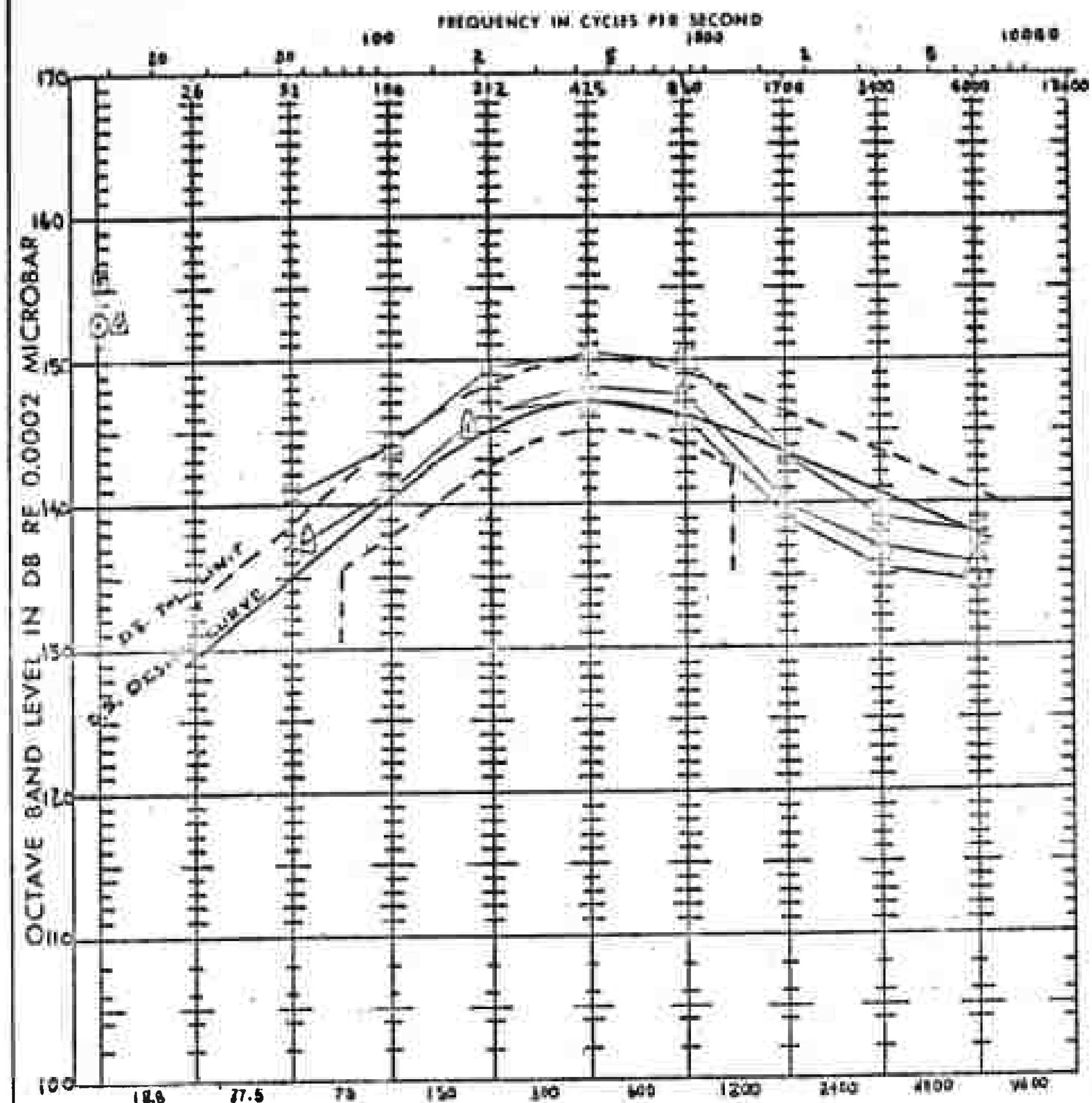
E.WA



EQUILIZER SETTINGS	○△	□
20 - 75	23.0	23
75 - 150	18.3	18
150 - 300	13.0	10
300 - 600	10.1	3
600 - 1200	2.8	-1.0
1200 - 2400	-1.0	∞
2400 - 4800	∞	∞
4800 - 9600	∞	∞
○ 4.0	50	
△ 4.0	50	
□ 4.3 AMPS	50	PSI

MIC #1

20376-1

○ PHASE A

△ PHASE B

□ PHASE C

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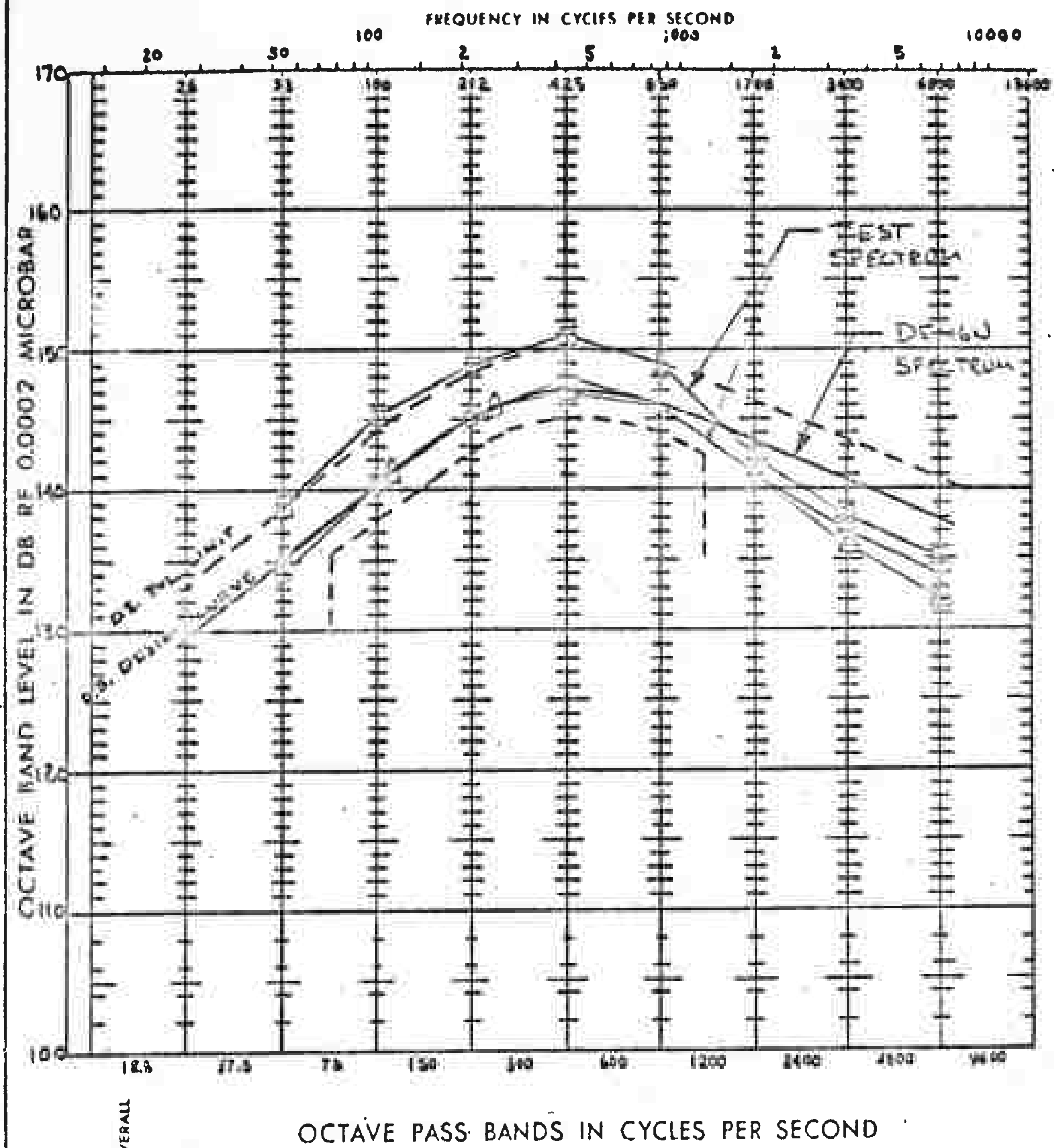
E.WA



EQUILIZER SETTINGS	O	Δ
20 - 75	23	28
75 - 150	15.5	21.5
150 - 300	16.5	22.0
300 - 600	10.0	11.7
600 - 1200	7.0	-1.0
1200 - 2400	-1.0	-1.0
2400 - 4800	∞	∞
4800 - 9600	∞	∞

O	3.4	52	
Δ	4.5	50	
□	— AMPS	50	PSI

MIC #1

25-20376-2

O PHASE A

Δ PHASE B

□ PHASE C

2-5353-7-7

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